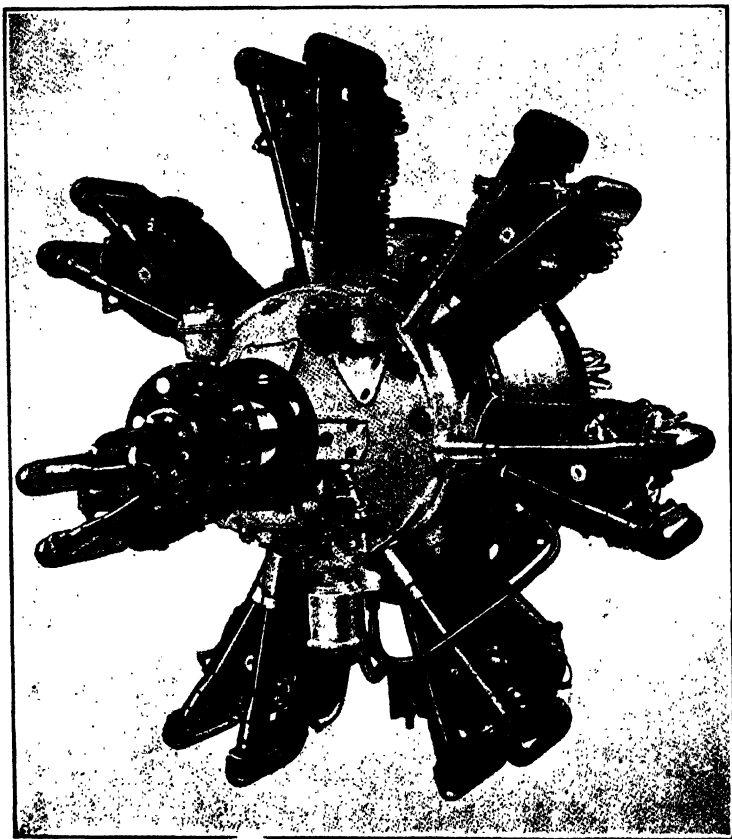


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Three-quarter front view of engine.

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**LYNX IV*
AERO-ENGINE**

Withⁿ Appendices on the
LYNX IV (MOD.) & LYNX IV ENGINES

This descriptive Handbook is published for the information
and guidance of all concerned.

By Command of the Air Council

C. L. Bullock

AIR MINISTRY

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LYNX IV (MOD.) AERO-ENGINE

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LEADING PARTICULARS

General

Type	Air-cooled static radial.
Number of cylinders	7.
Bore	5 in.
Stroke	5½ in.
Compression ratio	5 to 1.
Reduction gear	None.
Direction of rotation of crankshaft..	Left-hand tractor.
Normal r.p.m.	1900.
Maximum r.p.m.	2090.
B.H.P. at normal r.p.m.	205-215.
B.H.P. at maximum r.p.m.	220-230.
Numbering of cylinders (looking at front of engine).	1 to 7, clockwise. No. 1 vertical.

Lubrication

Oil specified for summer and winter use.	To Specification D.T.D. 109.
Oil consumption	3½-6½ pints per hour.
Normal oil pressure	75 lb. per sq. in.
Minimum oil pressure	60 lb. per sq. in.
Oil inlet temperature	70°C.
Oil outlet temperature	75°C.

Carburation

Fuel specified	To Specification D.T.D. 224.
Fuel consumption at normal r.p.m. . .	16 galls. per hour.
Type of carburettor	Zenith, type 65G—1.
Main jet calibration	640 c.c. per min.
Compensating jet calibration	340 c.c. per min.
Slow-running jet calibration	140 c.c. per min.
Choke tube bore	42 mm.

Ignition

Type of magnetos	B.T.H., S.C.7-1 (Fixed timing)
Port magneto timing	37° before T.D.C.
Starboard magneto timing	32° before T.D.C.
Firing order	1, 3, 5, 7, 2, 4, 6.
Direction of rotation of magnetos (looking at contact breaker).	Clockwise.
Magneto speed	¾ engine speed.
Sparking plugs	As specified in Air Publication 1260.

Valve timing

All valve tappet clearances (hot) ..	0.010 in.
Inlet valve tappet clearance (cold)..	0.020 in.
Exhaust valve tappet clearance (cold)	0.030 in.
Inlet valve opens with hot tappet clearance.	T.D.C.
Inlet valve closes with hot tappet clearance.	58° after B.D.C.
Exhaust valve opens with hot tappet clearance.	67° before B.D.C.
Exhaust valve closes with hot tappet clearance.	12° after T.D.C.

Installation

Overall diameter of engine	45.6 in.
Overall length of engine	46 in.
Pitch circle diameter of engine bearer bolt holes.	25 in.
Number of mounting bolt holes	16.
Dia. of mounting bolt holes.. .. .	⅜ in.

Note to Official Users

Air Ministry Orders and Volume II Leaflets as issued from time to time will affect the subject-matter of this publication. It should be understood that Amendment Lists are not always issued to bring the publication into line with the Orders or Leaflets, and it is for holders of this book to arrange the necessary linking-up.

Where an Order or Leaflet contradicts any portion of this publication, an Amendment List will generally be issued, but when this is not done the Order or Leaflet must be taken as the overriding authority.

Introduction

1. The Lynx IV* aero-engine is a seven-cylinder direct-drive, air-cooled, static radial engine. The cylinders are mounted around a barrel type crankcase, the pistons operating a one-piece crankshaft through a split connecting rod assembly of the master and articulated rod type. Each cylinder is fitted with one inlet and one exhaust valve, which are each operated through a rocker, push rod and tappet from a cam drum running in the crankcase unit in front of the cylinders. The method of attachment of the rockers to the cylinder heads provides compensation for the effects of cylinder expansion on valve clearances.

2. Carburation is by a Zenith 65 G—1 carburettor, and the mixture, after leaving the carburettor, passes through a heater box which is jacketed with warm oil from the crankcase. On leaving this component and entering the rear cover the mixture is atomised and distributed to the cylinders by means of a fan. The latter has no supercharging effect. Lubrication of the engine is effected by a pressure and a scavenge pump, the big-end bearing and wrist pins of the connecting rods being lubricated under pressure and the remaining components by splash. Ignition is provided by two B.T.H. magnetos, type S.C. 7-1, each magneto serving a sparking plug in each cylinder. A hand starter gear is fitted to the back of the crankcase.

3. It will be realised by those conversant with the Jaguar IVC engine that the Lynx IV* is in effect a Jaguar IVC engine employing but a single row of cylinders. The more important components in which the two engines differ are :—

- | | |
|------------------------------|--------------------------|
| (a) Crankshaft. | (f) Carburettor. |
| (b) Connecting rod assembly. | (g) Heater box. |
| (c) Engine body. | (h) Magnetos. |
| (d) Rear cover. | (j) Magneto drive shaft. |
| (e) Fan. | (k) Induction pipes. |

PART I—DESCRIPTION

CHAPTER I

ENGINE

Cylinder unit.

4. The cylinder unit comprises a mild steel barrel to which a cast aluminium alloy head is screwed and shrunk. To ensure that the head remains secure on the barrel when the cylinder is at working temperature, a chamfered steel ring is screwed to the upper end of the barrel and bears around the chamfered lower edge of the head. As the cylinder warms

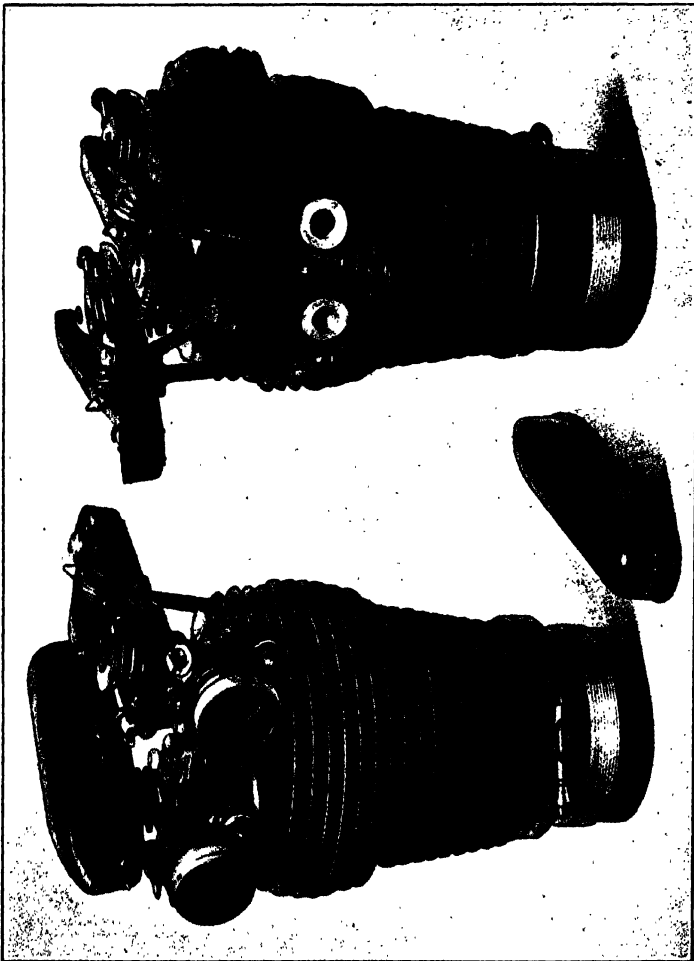


FIG. 1. Cylinders.

up, the head increases in diameter more than the barrel and ring owing to the coefficient of expansion of aluminium being greater than that of steel. The head is therefore forced to climb the chamfer of the ring. The angle of the chamfer is such that the head is raised from the barrel sufficiently to maintain the screw threads in forced contact at all temperatures. The device is shown in fig. 2.

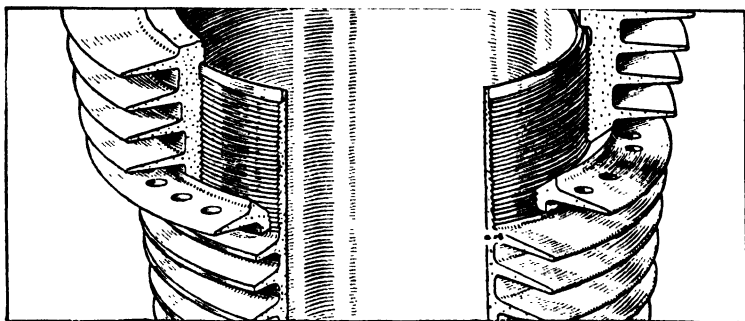


FIG. 2. Method of locking cylinder head.

5. The barrel is attached to the engine body by being screwed into a flanged adaptor mounted freely in the latter (*see* para. 31). It is locked and located radially by a split steel ring of wedge section; a square-headed bolt screwed into bosses adjacent to the split enables the ring to be contracted. When contracted, the ring, by bearing upon chamfered shoulders around the barrel and cylinder socket in the engine body, draws the flanged end of the adaptor up to a shoulder inside the engine body, as shown in fig. 3. The locating screw in the cylinder socket locates the adaptor whilst the cylinder is being screwed into position.

6. Nine cooling fins are machined eccentrically around the barrel beneath the head locking ring. Their shallowest portions are located at the front of the cylinder as excessive cooling with consequent distortion would occur at this point were their depth not decreased.

7. The cylinder head (shown in fig. 4) is an aluminium alloy casting, liberally finned around and above the combustion chamber and gas passages. The combustion chamber, which is dome-shaped, has two aluminium bronze valve seats screwed, shrunk and expanded into it on a diameter at right-angles to the axis of the crankshaft. The inlet valve seat is on the left when the head is viewed from the front with the rocker covers uppermost. The gas passage which communicates with each valve seat carries a phosphor bronze valve guide and terminates at the rear of the head in a bolted-on

steel flange for the reception of an induction or exhaust pipe connection. A boss for a priming atomiser is provided in the inlet gas passage in front of the flange for the induction pipe connection. Of the two flanges, each of which is attached to the head by three studs, that fitted to the inlet gas passage incorporates a screwed extension to receive the nut securing the induction pipe to it, whilst that fitted to the exhaust gas passage provides a grooved stub around which the exhaust pipe connection is clamped by a locking ring. The latter is

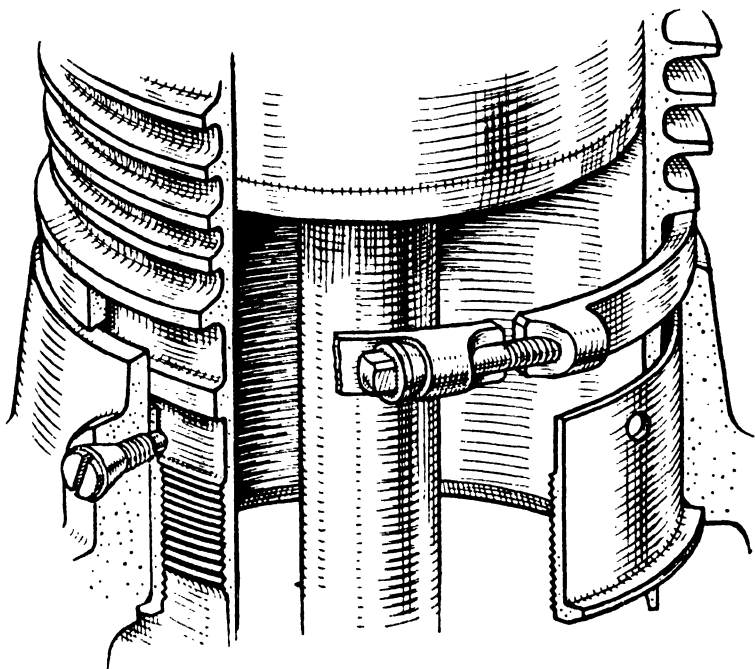


FIG. 3. Mounting and locking of cylinder barrel.

contracted by a screw inserted through bosses formed adjacent to the split. There is a stud-like projection on each flange for the attachment of the rear end of the rocker casing. An adaptor for a sparking plug is screwed and pegged into the front of the head beneath each valve seat and a similar adaptor is fitted in a like manner between the two sparking plug adaptors to receive a gas starter non-return valve. This adaptor is normally fitted with a duralumin blanking plug. Two studs for ignition cable clips are fitted between the rocker casings.

8. The rockers are mounted in the forked ends of rods secured by nuts to lugs on the front of the cylinder head. The rods are tied together at their outer and inner ends by a built-up bracing structure shaped like an X; the assembly thus formed is known as the rocker bracket. The nuts which retain the ends of the bracing structure to the outer ends of the rods also retain the front ends of the rocker casings. The bracket is attached to the cylinder head in such a position that it provides compensation for the effects of cylinder expansion on valve tappet clearances in the following way. As soon as the engine is run, the cylinder barrels warm up and expand, but the rocker brackets, being in the slipstream of the airscrew, remain cool and do not expand by any appreciable amount. The expansion of the cylinder barrels causes the rocker brackets, rockers and valves to travel outwards. This movement, by itself, would increase the valve tappet clearances, since the push rods remain practically unaltered in length. At the same time that the cylinder barrels are expanding, the cylinder heads and valve stems also expand. This movement tends to decrease the valve tappet clearances by bringing the ends of the valve stems closer to the rocker striking pins, and thus provides the correct clearances.

9. The inlet and exhaust valves are both of the tulip type; the diameter of the head of the stainless steel inlet valve is slightly greater than that of the exhaust valve, which is of cobalt chrome steel. Both have stellite tips built up on the ends of their stems. A pair of concentric coil springs retains each valve to its seat. Each pair of springs bears at its inner end upon a washer spigoted around the outer end of the valve guide and at its outer end upon a second washer secured by a split cotter sleeve to the valve stem. Each half of the cotter sleeve is marked, the respective valve and cylinder number being etched on the top face, *e.g.*, X.3, exhaust, No. 3. Valves are marked for their respective cylinders and ports inside the valve heads; valves and cotter sleeves are not interchangeable. Each cotter sleeve has several corrugations in its bore to engage like corrugations around the valve stem. A spring circlip is fitted in a groove beneath the innermost corrugation on the valve stem and prevents the valve from falling through the guide after the outer spring washer has been removed. A shoulder around the face of each valve spring washer locates the springs concentrically with the valve stem. The shoulder bears around the outside of the inner spring and around the inside of the outer spring.

10. The valve rockers are steel forgings of the shape shown in fig. 4. Each rocker is supported near its centre upon two single-row ball bearings; the inner races of the bearings are mounted on a fulcrum bolt in the rocker bracket

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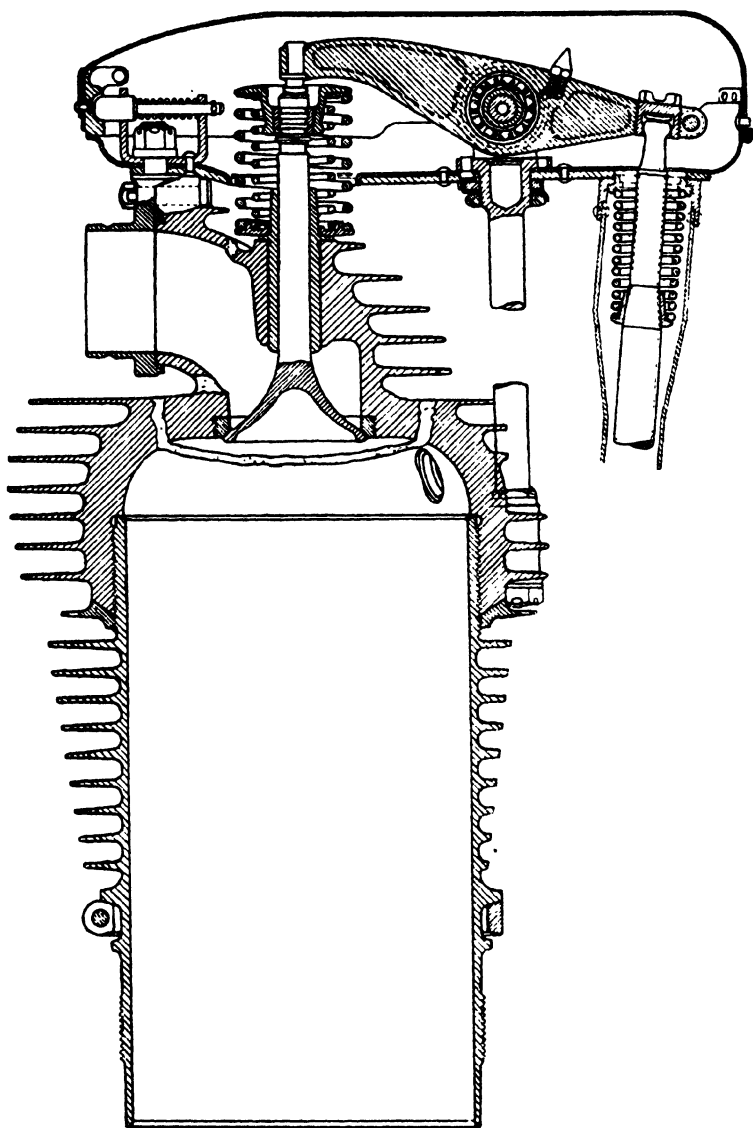


FIG. 4. CYLINDER UNIT.

and are separated by a distance piece carried on the bolt. The outer races are separated by a shoulder around the bore of the bearing housing in the rocker. Lubrication of the bearings is provided for by a grease nipple screwed into the rocker, grease injected being forced through a duct drilled in the rocker into the space between the two bearings. The valve-operating end of the rocker is fitted with a case-hardened striking pin, riveted in position, whilst the push rod operated end is split and tapped to receive a steel sleeve. This externally-threaded sleeve carries a case-hardened steel thrust pad against which the end of the push rod bears. When adjusted to give the correct valve tappet clearance the sleeve is locked by a clamping bolt through the end of the rocker. The thrust pad is disc-shaped and is a loose fit in the bore of the sleeve but must be sprung into position past a shoulder near the mouth of the sleeve. The pad has cylindrically ground faces which provide line rolling contact with both the push rod and the sleeve. The axes about which the faces of the pad are ground are disposed at right-angles to each other and thus provide a universal thrust joint between the push rod and sleeve.

11. Each rocker is enclosed by a two-piece pressed aluminium casing approximately streamline in shape, the two portions being secured to each other by a dowel at the front and by a spring bolt, which registers with a recess in the outer half casing, at the rear. The inner portions of the casings are mounted clear of the cylinder heads on the vertical studs which are integral with the inlet and exhaust flanges, at the rear, and on the outer ends of the rods which support the rockers, at the front.

Piston

12. The piston, which is a Y-alloy forging, has a concave crown and is fitted with two compression rings and one scraper ring in grooves between the crown and gudgeon pin bosses. All these rings are free to float in their grooves and are diagonally jointed. The compression rings are of rectangular section, but the scraper ring, which is fitted below the compression rings, is of channel section. Numerous transfer holes are drilled around the scraper ring and around the base of its groove in the piston, as shown in fig. 5. Additional holes are also drilled in a chamfer below the scraper ring and between the gudgeon pin bosses. The tubular gudgeon pin floats in its bosses in the piston and is located between two circlips sprung into the ends of the bosses. The number of the cylinder in which the piston operates is stamped on the crown, and the piston is assembled so that the number is nearest the front of the engine.

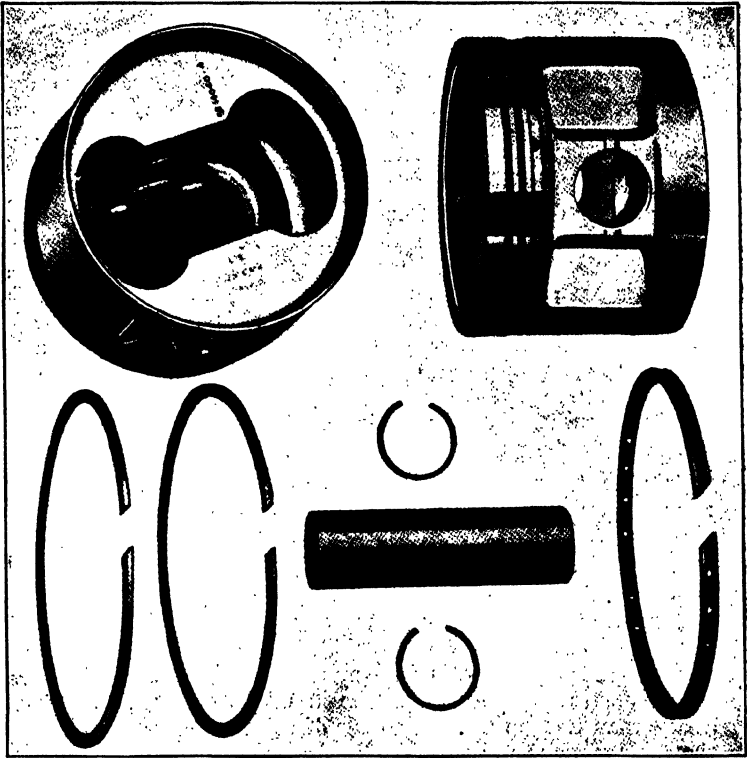


FIG. 5. Pistons, gudgeon pin, etc.

Connecting rod assembly

13. The connecting rod assembly, as may be seen from fig. 6, is of the master and articulated rod type. The master rod has a shank of H-section and provides a big-end to house a white-metalled steel bearing shell. The big-end is flanged and the flanges are drilled to receive the ends of the case-hardened wrist pins by which the articulated rods are attached to it. It is split, as shown in fig. 7, so that the jaws of the cap include more than 180° , but they are opened out to the full diameter of the bearing shell. The latter is split across a diameter, and the cap portion is provided with lugs which engage a peg fitted in each side of the master rod cap. No oil grooving is effected in the bearing. Four bolts secure the cap to the rod and break into the sockets for four of the wrist pins. These wrist pins are parallel-sided and are light drive fits in their sockets. The ends are notched to clear the shanks of the

retaining bolts, which locate them. The two remaining pins are stepped in diameter at one end and are drive fits in their sockets. End location of these pins is effected by circlips sprung into the outer ends of their sockets in the master rod cap. The four notched pins are bored eccentrically and the plain pins concentrically.

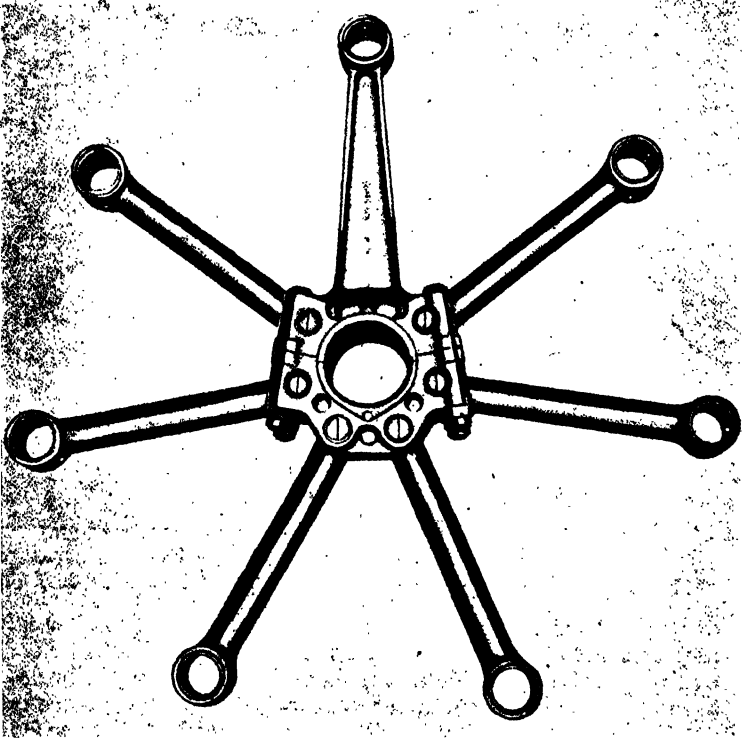


FIG. 6. Connecting rod assembly.

14. Lubrication of the wrist pin bushes is effected as shown in fig. 8. Holes drilled through the big end bearing shells, master rod and cap transfer oil from the bearing to the wrist pin sockets in the master rod and cap. Each of the wrist pins is plugged at each end by means of a duralumin plug screwed into the pin. Two circumferential grooves machined near the ends of the pin register with the oil holes in the sockets in the master rod and cap and convey the oil to the bore of the pin, whence it escapes by four holes to two oil grooves machined in that portion of the pin on which the articulated rod bears.

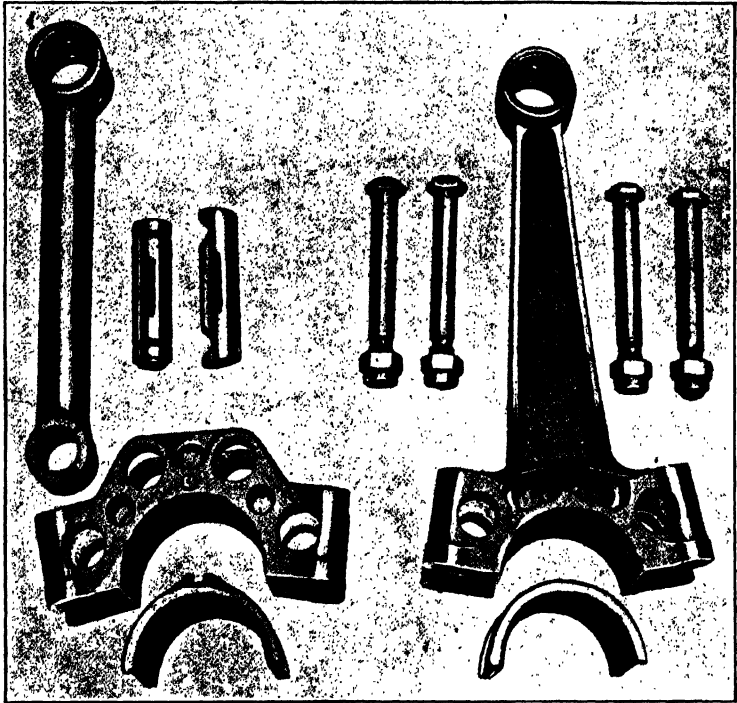


FIG. 7. Connecting rod components.

15. The gudgeon and wrist pin bushes are shrunk into the articulated rods, which have tubular shanks, each bush being further secured by two plugs screwed into the rod and bush and peened flush outside and inside. The gudgeon pin bush in the master rod is secured in a similar manner. The gudgeon pin is lubricated by oil mist, four holes being drilled through the rod and bush. There is a small vent hole in the shank at the wrist pin end of each articulated rod, the connecting rod assembly being fitted in the engine so that the holes trail.

16. An earlier type of connecting rod assembly, which is now obsolescent, is similar to the type described above, but it embodies floating gudgeon and wrist pin bushes and splash lubrication of the wrist pins. This assembly is identical with that fitted to the Jaguar IVC engine. The gudgeon pin bushes are lubricated by oil mist entering through the large holes in the rods through which the shanks are bored, and the wrist pin bushes by oil mist which enters through five holes drilled in the rods. The bushes themselves are also drilled so as to transfer oil to the pins about which they work. The master

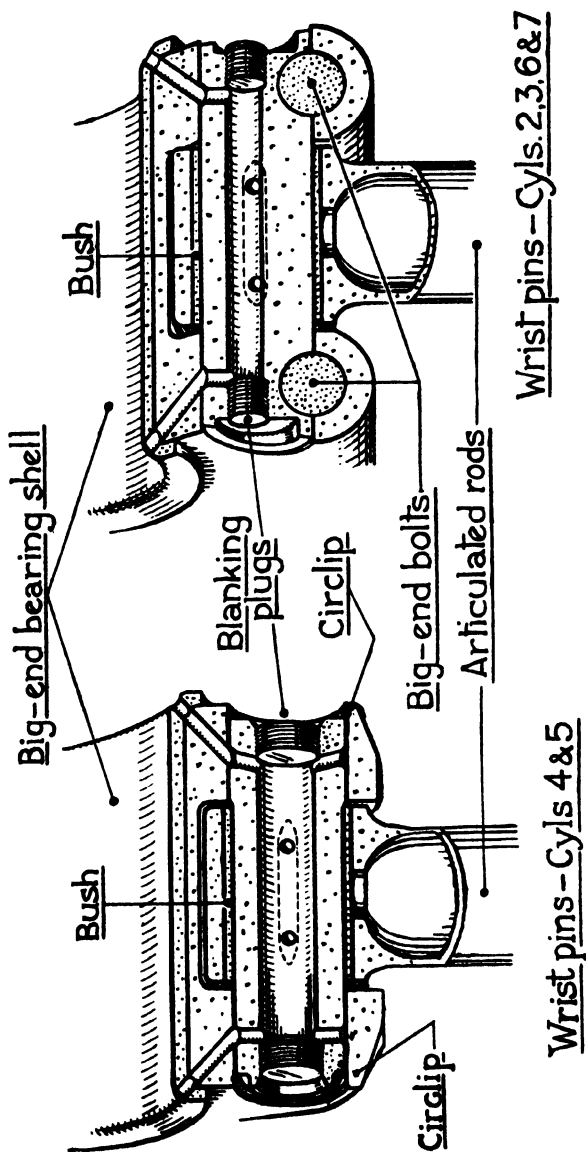


FIG. 8. WRIST PIN ASSEMBLIES

rod, cap and white-metalled shells are similar to the later type, except that no oil holes are drilled through them for pressure lubrication of the wrist pins.

Crankshaft

17. The single throw crankshaft is of the one-piece type and is balanced by brass weights fitted to extensions of the crankwebs. Three bolts and a spigot retain each balance weight in place. The shaft and crankpin are bored for purposes of lightness and lubrication, the bore of the shaft communicating with that of the pin by a duct drilled in the front crankweb. The shaft is bored from its front end to within a short distance of the rear face of the front crankweb ; the crankpin is bored completely through. A duralumin plug, which is a drive fit in the bore, seals the front end of the shaft, in which it is retained by a grub screw. Provision is made for the withdrawal of the plug by the machining of a thread in its mouth, a special withdrawing tool being supplied in the tool kit. The bore of the crankpin is sealed at the front end by means of a duralumin plug, and at the rear end by a steel cap ; both cap and plug are drawn up on to flat seatings in the ends of the crankpin bore by a nut screwed on to the shank of the plug (*see* fig. 9). The nut is split-pinned, and the whole assembly is prevented from turning by means of a plug screwed into the outer end of the oil duct in the front crankweb so as to engage a slot in the sealing plug.

18. The shaft is supported in three roller bearings of which two are main bearings and one is a steady bearing. The main bearings are mounted one on each side of the crank throw, whilst the steady bearing is positioned towards the front end of the shaft behind the airscrew hub. The shaft is continued for a short distance to the rear of the mounting for the rear main bearing and provides a mounting for the fan. The fan is retained on its mounting by a hollow shouldered plug screwed into the end of the shaft. This end of the shaft is bored completely through to several different diameters, and houses an internally serrated plug. The plug is located just forward of the screwed plug previously mentioned and clips an aluminium cap between its front face and a shoulder in the bore of the shaft. This cap seals the crankcase against oil leakage. The internally serrated plug transmits the drive to the magnetos and to the engine speed indicator drive unit. It in turn receives the drive from the crankshaft through six pegs driven and peened into sockets drilled radially around the fan mounting. It is a light drive fit in its socket in the crankshaft.

19. Forward of the mounting for the front main bearing the crankshaft is reduced slightly in diameter. Here it provides the mounting for the two bearings of the cam drum

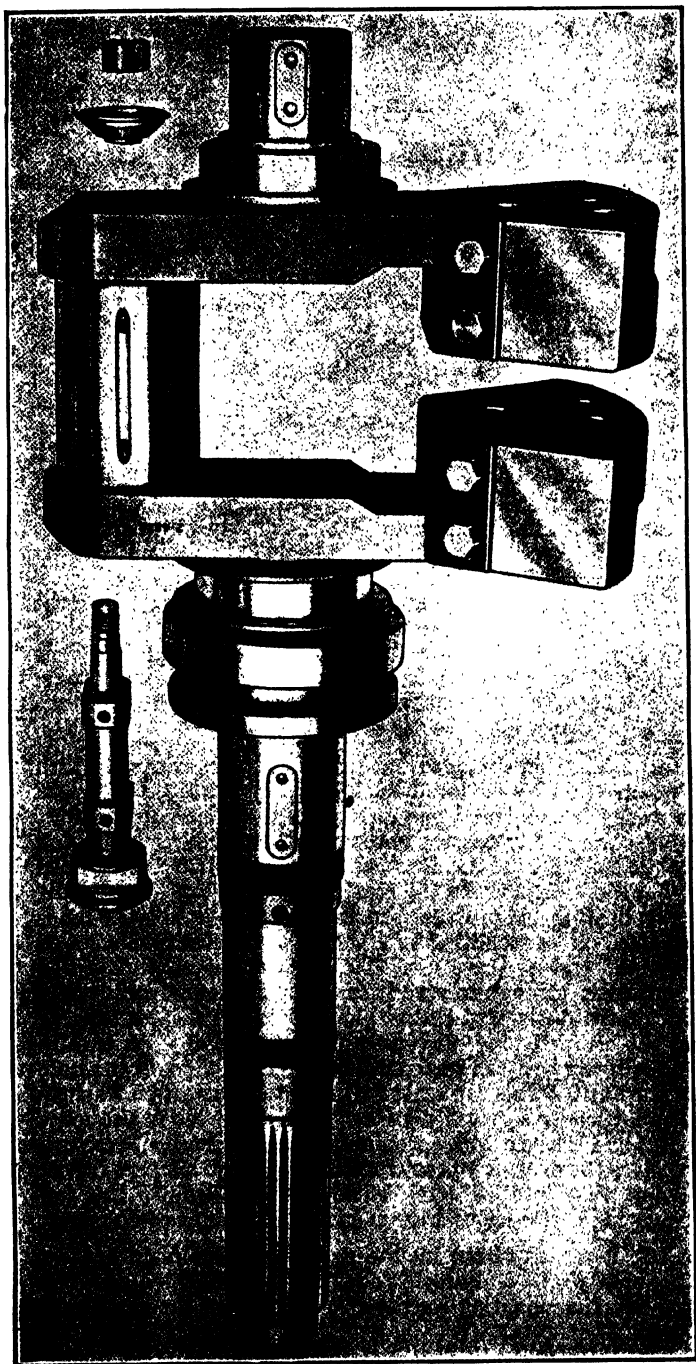


FIG. 9. Crankshaft.

and for a sleeve from which the cam drum and oil pump are driven. This sleeve is known as the driving sleeve. It has a spur gear machined centrally upon it for the drive to the cam drum, and a skew gear for the drive to the oil pump at its front end. The driving sleeve is keyed to the shaft and is retained thereon by a ring nut, known as the crankshaft rear lock nut. Forward of its castellated head, this nut is provided with a cylindrical shank around which a spiral oil-retaining groove is machined. A short distance in front of the nut the shaft is again reduced in diameter and accommodates a long sleeve known as the thrust bearing carrier. The rear end of this component is of the same diameter as the shank of the crankshaft rear lock nut, and is machined with a spiral oil groove of opposite hand to that on the nut. This portion of the thrust bearing carrier and the cylindrical shank of the lock nut form oil-retaining joints in the ends of a chamber in the front cover of the crankcase assembly. Oil, fed to this chamber under pressure, is led to a space between the ends of the lock nut and thrust bearing carrier. From here it enters the crankshaft through two diametrically opposite holes drilled radially in that component.

20. Forward of its oil-retaining portion, the thrust bearing carrier is flanged; forward of the flange, it is reduced in diameter and provides the mounting and anchorage for the rearmost of two thrust rings. It projects through the bore of these rings and its front end provides the anchorage for the inner race of the steady bearing previously mentioned. Some engines are fitted with an earlier type of thrust bearing carrier which has no flange between the oil-retaining portion and the mounting for the thrust rings. The inner race of the steady bearing, and hence the thrust bearing carrier, are retained in place by a nut screwed on the shaft. The rear end of this nut is cylindrical and is machined with a helical oil groove. It rotates in the bore of a duralumin cover plate, which seals the mouth of the thrust housing in the front cover of the crankcase, and makes an oil-retaining joint in the bore of the plate. Two dogs are machined on the front face of the castellated head of the nut and engage sockets in the rear face of the rear centring cone of the airscrew hub. This nut is known as the crankshaft front lock nut.

21. A short distance in front of the nut the crankshaft is serrated to transmit the drive to the airscrew hub. Forward of this serrated portion it is reduced in diameter to provide the mounting for the front centring cone of the hub. This cone, and the airscrew hub, are retained in position by a plug screwed into the end of the shaft. One of the serrations is left blank to ensure that the hub can be assembled in one position only with respect to the shaft.

22. Some engines are fitted with an earlier, but similar, type of crankshaft, of the standard Lynx IV type, rebalanced to suit the strengthened connecting rod assembly which is fitted to the IV*. Rebalancing is effected by attaching a balance weight plate to each balance weight by means of four bolts, locked with tab washers. This modification is illustrated in fig. 9. Also, instead of a blank serration being left in the serrated portion of the shaft, a peg is fitted between a pair of serrations to ensure correct assembly of the hub.

23. The two main bearings are both of the uncaged roller type. Each has an L-sectioned inner race upon which the rollers are located axially by a heavy guard or shroud washer. The washer for the rear bearing is mounted between the rear face of the race and the fan hub, that for the front bearing being mounted between the front face of the race and the rear bearing of the cam drum. The outer race of the rear bearing is of channel section and hence permits no end float of its rollers. The outer race of the front bearing is a plain ring and therefore permits free axial float of its rollers. The small steady bearing is also of the uncaged roller type and has a channel-sectioned inner race and a plain ring outer race. It is mounted on the shaft immediately in front of a two ring double-acting thrust bearing. This bearing and the components of the thrust bearing are located in a housing formed in the front cover of the crankcase assembly.

24. As has been stated above, the thrust bearing comprises two thrust rings of which the rearmost is located towards the rear end of the thrust bearing carrier. The front ring is mounted on the front end of the carrier and abuts against the inner race of the roller bearing (*see* fig. 10). The length of the thrust bearing carrier is such that the two thrust rings and their ring of caged balls have a small amount of end float between the shoulder of the thrust bearing carrier and the inner race of the roller bearing. The outer edges of the two thrust rings float between the internal lips of two cylindrical distance pieces of L-section. These distance pieces are mounted in the thrust housing, in which they are held firmly by the duralumin plate bolted to the mouth of the housing. The spacing of the lips of the distance pieces allows the thrust rings a small amount of end float.

25. The distance pieces are light push fits in the housing. Provision is made for their axial adjustment by the insertion of an adjusting washer between the rearmost distance piece and the back of the housing, and between the outer race of the roller bearing and the duralumin plate that seals the thrust housing.

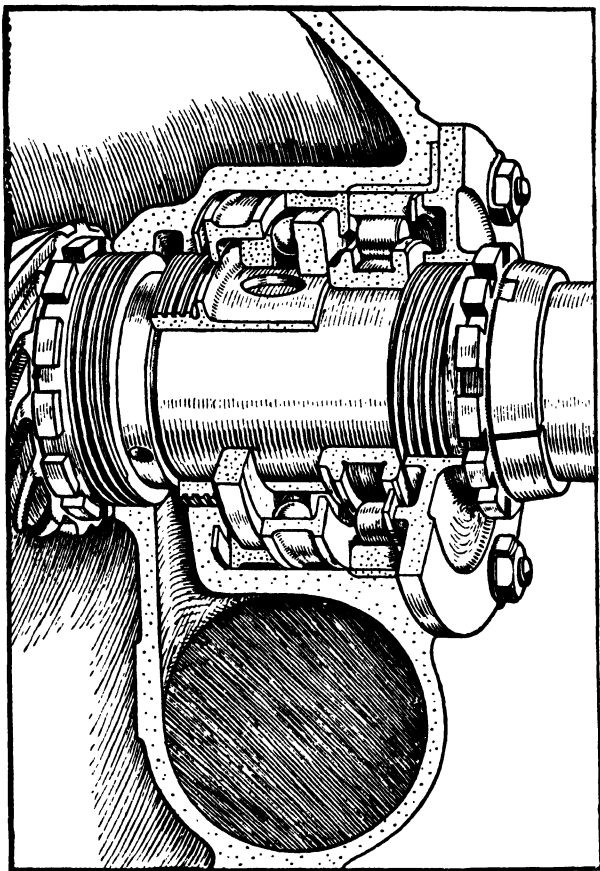


FIG. 10. Thrust housing.

26. The operation of the bearing is illustrated in fig. 11. When the aeroplane is flying normally the airscrew thrust is applied through the shoulder of the thrust bearing carrier. From the carrier it is transmitted through the two thrust rings and their ring of caged balls to the internal lip of the front outside distance piece. This component is anchored to the crankcase assembly through the outer race of the roller bearing, the adjusting washer and the thrust housing cover. Under these conditions a clearance exists between the front thrust ring and inner race of the roller bearing, and between the rear thrust ring and the internal lip of the rear outside distance piece.

27. When the airscrew thrust is reversed, as occurs when the aeroplane is diving with closed throttle, the thrust is applied to the crankshaft front lock nut. It is transmitted from this component to the inner race of the roller bearing. From the inner race of the roller bearing the thrust passes through the two thrust rings and their ring of caged balls to the internal lip of the rear outside distance piece. The thrust from the distance piece is transmitted through the adjusting washer to the rear wall of the thrust housing. Under these conditions a clearance exists between the front thrust ring and the internal lip of the front outside distance piece, and between the rear thrust ring and the shoulder of the thrust bearing carrier.

28. In changing over from the first position to the second the crankshaft moves axially. In doing so it moves the rollers of the front main bearing and steady bearing axially in their outer races. There is no appreciable end float of the rollers in the outer race of the rear main bearing. Consequently the outer race is moved axially in its housing on the reversal of the airscrew thrust. It will be realised from figs. 10 and 11 that the adjusting washers take no part in the adjustment of the end float of the crankshaft, but simply effect the correct location of the shaft in the engine.

Crankcase assembly

29. The crankcase assembly comprises the following components :—

- (i) Engine body.
- (ii) Front cover.
- (iii) Fan induction casing.
- (iv) Rear cover.
- (v) Engine bearer.

30. The crankcase proper is formed by the engine body, which provides the cylinder sockets and also houses the valve cam gear. The front end of the engine body is closed by the front cover, which component also houses the thrust bearing assembly. In addition to this, the front cover provides mountings for the oil pump, breathers and for three cowling supports. The fan induction casing seals the rear face of the engine body, accommodates the fan and provides sockets for the inner ends of the seven induction pipes. The rear face of the fan induction casing is in turn closed by the rear cover, upon which component are mounted the two magnetos, engine speed indicator drive unit, heater box and hand starter gear. The engine bearer, which is attached to the engine body, provides the mounting for the engine in the airframe.

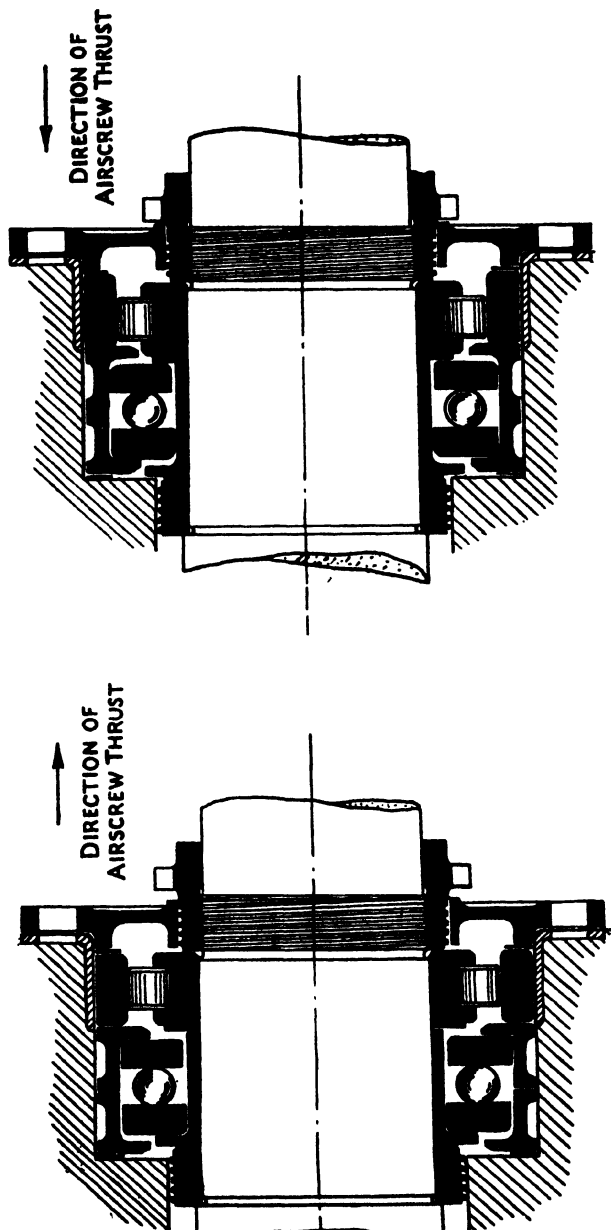


FIG. II.

ACTION OF THRUST BEARING.

Engine body

31. The engine body, in common with all the components of the crankcase assembly, with the exception of the engine bearer, is machined from an aluminium alloy casting. It is of the barrel type and the sockets for the accommodation of the cylinders are machined around its periphery, as shown in figs. 12 and 13. These sockets are bossed up well above the surface of the engine body, which is stiffened by webs cast between the sockets. A boss is cast on the front face of each socket to accommodate a cylinder adapter locating screw. The outer edges of the cylinder sockets are chamfered off to mate with the inner surfaces of the cylinder barrel locking rings. An internal flange is cast towards the front end of the engine body and carries the steel housing for the outer race of the front main bearing. An irregularly shaped ring is cast on the front face of this flange.

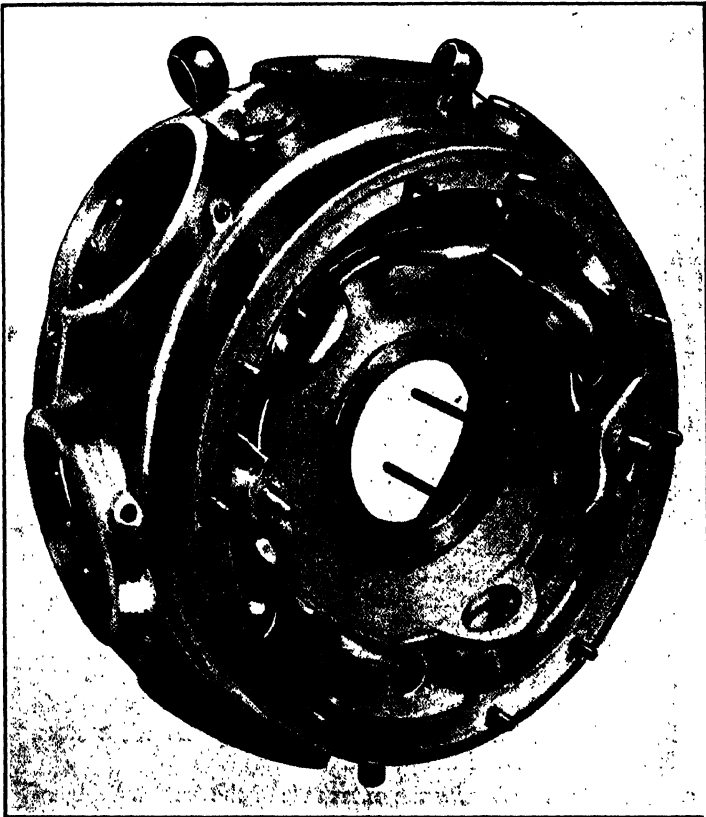


FIG. 12. Engine body, front view.

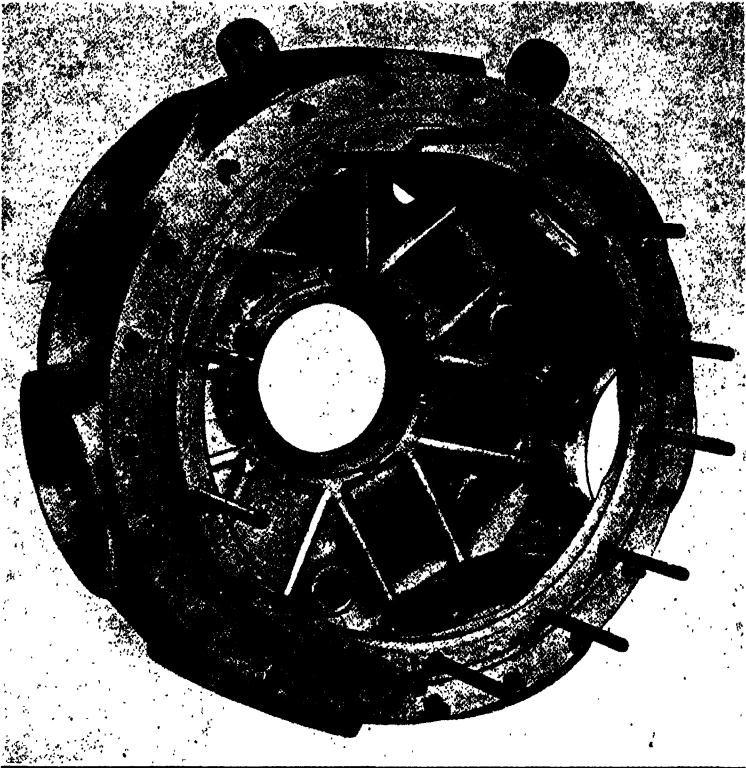


FIG . 13. Engine body rear view.

32. Sockets for seven tapped guides are machined in the walls of the ring and in an extension of the engine body concentric with it. The cam drum is accommodated in the bore of the ring cast in the front of the engine body. A socket is machined on each side of No. 1 cylinder socket towards the front end of the engine body. These sockets, which formerly accommodated breathers, are now blanked off by means of plugs and fibre washers. A socket is also provided to the rear of each blanked socket for mounting a lifting eyebolt. Oil condensing on the walls of the engine body drains down to a pocket formed between Nos. 4 and 5 cylinder adaptors. From here it is withdrawn by the scavenge pump through a union fitted in the base of the pocket.

33. The housing for the outer race of the front main bearing is of steel, and is shrunk into its socket in the engine body. It is inserted from the rear end of its socket and a ring nut is

screwed to its front end. This draws a shoulder around the rear end of the housing up against the rear face of the flange in the engine body. The housing is prevented from creeping in its socket by a number of dogs which project radially from around its flange. These engage notches in a lip around the seating in the engine body for the flange. The end of the housing is peened over the nut to prevent the latter from slacking back. The race is located axially between an internal lip formed at the front end of the housing and a ring sprung into a groove machined at the rear end of the housing. Provision is made for the attachment of the front cover by a ring of studs fitted around the front end of the engine body. The rear end of the engine body is open and has two concentric seatings machined around it, one for the attachment of the engine bearer and one for the attachment of the fan induction casing. A number of retaining studs are fitted around each seating.

Front cover

34. The front cover is of the shape shown in fig. 14, and in its nose is formed a housing which accommodates the thrust and steady bearings. To prevent wear of the housing due to creeping of the outer race of the steady bearing, a flanged cylindrical steel liner is shrunk into it and is prevented from turning by six dogs which project radially from around the flange. These dogs engage notches recessed in the face of the front cover; the studs securing the duralumin cover plate to the front cover project through holes in the flange of the liner. A cylindrical chamber is cast transversely across the nose of the front cover immediately below the thrust housing. This chamber accommodates the feed pump oil filter and serves a chamber at the back of the thrust housing. It is in turn fed by a duct taken to a port cored in a horizontal facing machined immediately below it. This seating provides the mounting for the oil pump and for a cowling support. The left-hand end of the filter chamber (when viewed from the front of the engine) is closed by an aluminium cap screwed into place. A lifting eyebolt is screwed into the cap, but when in this position must not be employed for lifting the engine. The eyebolt is to be screwed into the end of the crankshaft before it may be used for this purpose. The opposite end of the filter chamber is fitted with a twin-type union to provide attachments for the capsule fittings of transmitting type oil pressure gauges.

35. A socket is provided high up on each side of the cover for the reception of a breather. The sockets communicate with chambers formed by two vertical webs in the interior of the cover. Each chamber is sealed by a sheet aluminium

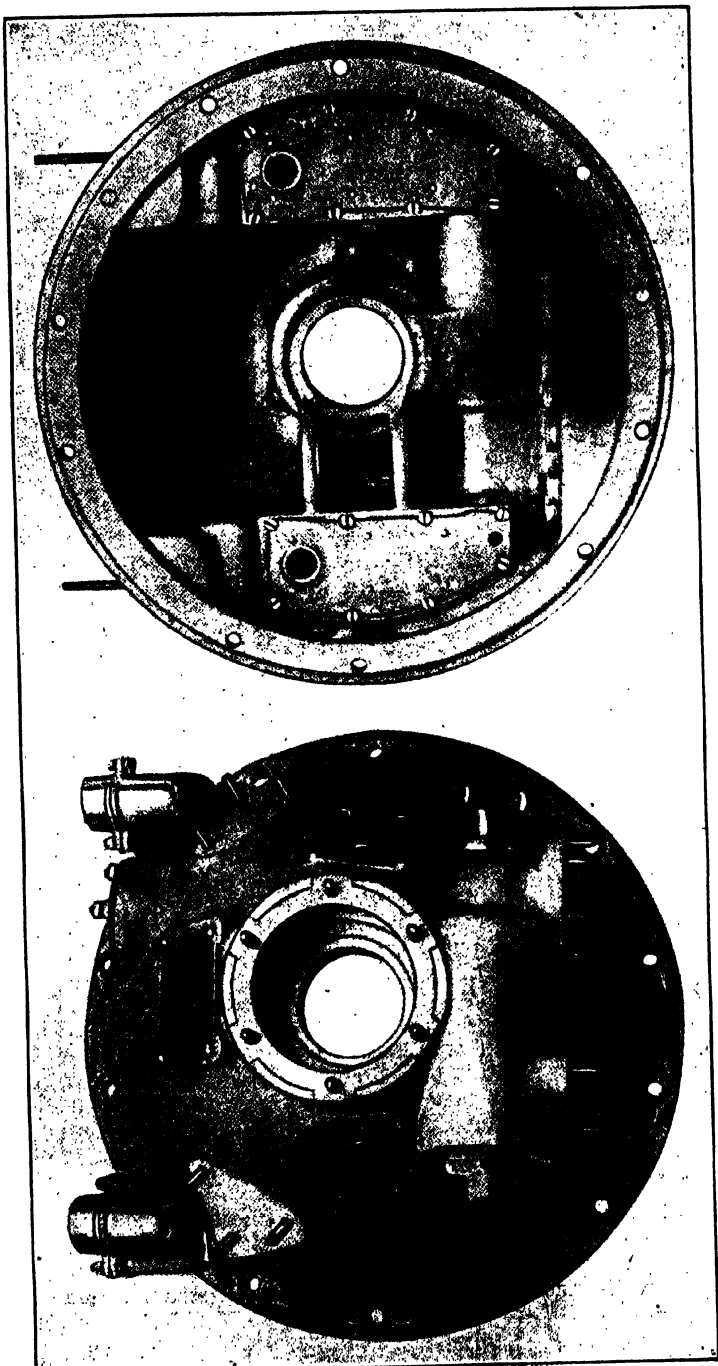


FIG. 14. Front cover.

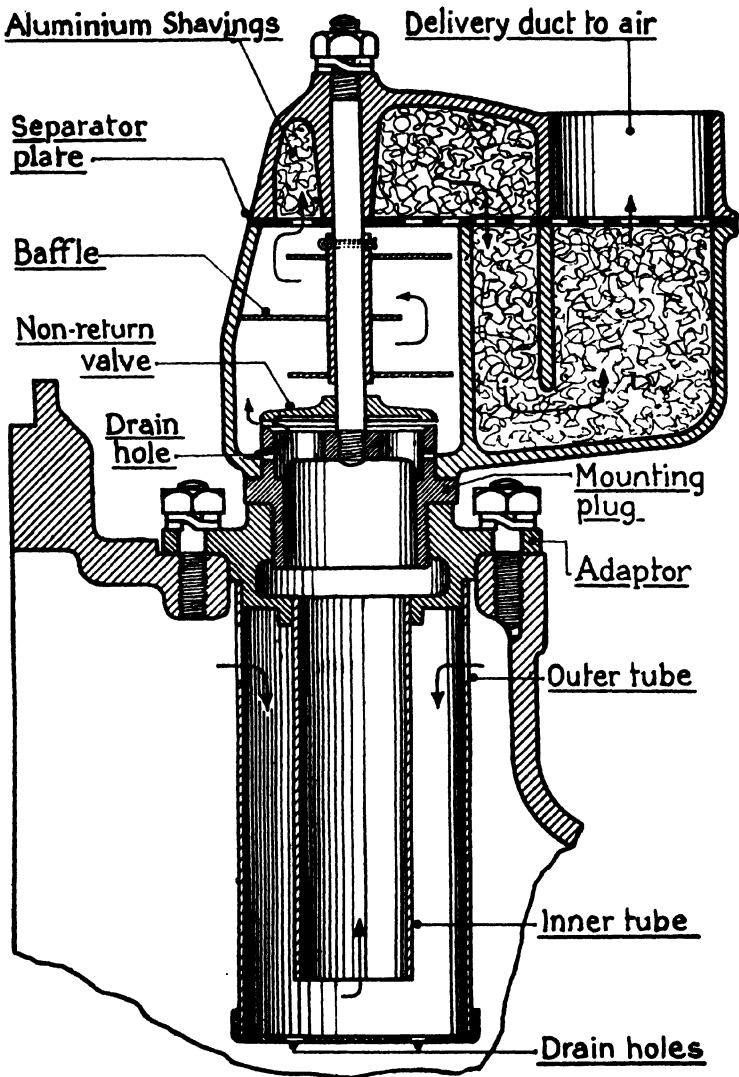


FIG. 15. BREATHER AND EXTENSION AS FITTED TO EARLY TYPE FRONT COVER

cover, known as the breather plate, which is attached to the front cover by eight screws. Two holes in the breather plate put the chamber into communication with the front cover; the upper hole, which has a lip formed around it, communicates with a vertical duct formed by a baffle riveted to the breather plate; the lower hole allows oil to drain back to the interior of the front cover.

36. A seating to which a gas starter distributor may be attached is provided on the right-hand side of the front cover. Normally this seating is blanked off by an aluminium cover plate. Two webs are cast in a horizontal plane in the interior of the front cover and are machined with sockets. The socket in the lower web steadies the upper end of the oil pump driving spindle standard. The socket in the upper web steadies the lower end of the gas starter distributor (if fitted). Two facings are machined on each side of the front cover and provide the mounting for a cowling bracket and a gun synchronizing gear tappet in each case. Gun synchronizing gear tappets are not standard fittings. Owing to the spacing of its retaining studs the cover can be erected in one position only.

37. An earlier type of cover, similar to that described above, but not provided with breather sockets or baffle chambers, will be found fitted to most Lynx IV* engines which have been reconditioned from the IV standard. A single breather only is fitted to these engines. The cover plate for the gas starter seating is replaced by an adaptor into which is screwed one of the breathers that was formerly fitted in the engine body. The adaptor carries two concentric tubes which act as baffles to prevent oil being thrown into the breathers. This component is known as the breather extension and projects downwards into the front cover as shown in fig. 15. The outer of the two tubes has a cover silver-soldered to it at its lower end. Vapour under pressure inside the crankcase assembly enters the space between the inner and outer tubes through holes drilled around the upper end of the latter, and then passes into the breather by way of the bore of the inner tube. Oil draining back from the breather and extension tubes returns to the front cover through holes drilled in the cover of the outer tube.

Fan induction casing

38. The fan induction casing (fig. 16) is a hollow box-like casting, closed at its front end and open at its rear end. Its front end provides a socket for the housing of the outer race of the rear main bearing. Like that of the front main bearing the housing is shrunk into its socket in which it is retained by a ring nut. This nut draws a shoulder formed around the rear

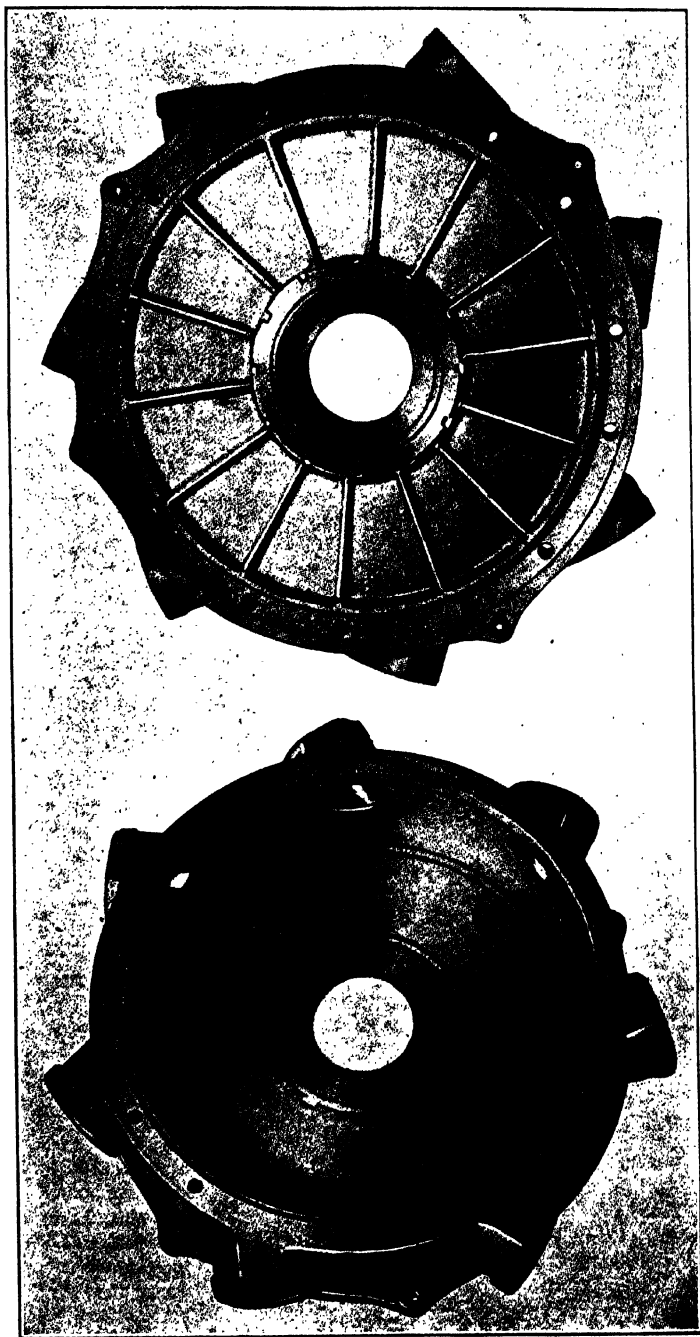


Fig. 16. Fan induction casing.

end of the housing up against its seating. The housing is prevented from creeping in its socket by a notched flange, as in the case of the front bearing housing. The end of the housing is peened over on to the nut to prevent the latter slacking back. The rear end of the bearing housing has a deep internal lip on which a seating is ground for the engagement of a gland mounted on the front end of the fan hub. An oil hole is drilled at an angle through the end wall of the fan induction casing to break into the bearing housing, which it feeds with oil draining down the front face of the casing.

39. Seven equally-spaced sockets are formed around the periphery of the casing and accommodate the inner ends of the induction pipes. Shoulders machined in the bores of the sockets prevent the induction pipes from slipping into the casing during assembly, thereby damaging the fan. Early type induction casings are not provided with these shoulders, but stop screws are inserted through the walls of the sockets. The stop screws are locked by means of slotted nuts and split pins. The bores of the sockets each house a single ring of Dermatine packing of trapezium section. Duralumin washers are fitted on the two converging sides of the packing, which is compressed around the induction pipe by a gland nut screwed into the mouth of the socket. A boss is provided on the outside of each socket to accommodate a steel plate for locking the gland nuts. Each plate is attached to the boss by means of two screws, locked with wire. Fourteen long studs retain the fan induction casing to the engine body, and a dowel peg fitted to the latter component ensures its correct assembly. Four lugs are provided around the seating by which the casing is attached to the engine body and are fitted with threaded bushes for the engagement of extractor bolts. In some instances engines may be fitted with fan induction casings of which the extractor bolt holes are drilled and tapped on nearly the same pitch circle as the holes for the retaining studs. Such engines have been converted from the Lynx IV standard.

Rear cover

40. The rear cover seals the back of the fan induction casing and provides a transfer passage of increasing cross-section for the mixture on its way from the heater box to the fan induction casing. The heater box is attached to the lower end of the elbow-shaped transfer passage formed in the rear cover. The front end of this passage is jacketed with warm oil which is being returned by the scavenge pump to the tank. The unions for the inflowing and outflowing oil are shown in fig. 17, which also shows two blanking plates which are fitted to seal core holes in the jacket. A box-like

extension is cast on the back of the gas passage and provides mountings for the two magnetos, the engine speed indicator drive unit and the hand starter gear. The magnetos are spigoted to the sides of the casing to which they are each secured by three studs and nuts. Their driving bevels project into the interior of the extension, where they are engaged by a third bevel wheel. This wheel is fitted to a shaft which projects through a boss cast on the back of the gas passage proper and has its front end engaged in the plug in the rear end of the crankshaft.

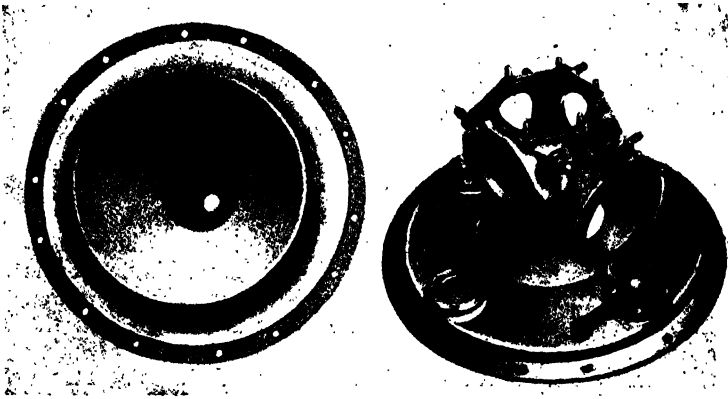


FIG. 17. Rear cover.

41. A felt-packed steel gland renders oil-tight the joint between the shaft and the boss through which it passes. The rear end of the extension bears a plate which carries the bearing in which the rear end of the magneto drive shaft is supported. The upper face of the extension provides a mounting for the engine speed indicator drive unit. The extension incorporates an oil sump from which the magneto bevel wheels obtain their lubrication. The sump is filled by hand from an oil filler cup fitted to the engine speed indicator drive unit, whilst an overflow cock is provided in its base. A plug is fitted in the walls of the gas passage just forward of the extension and seals a socket, provided originally for a priming nozzle. Another plug is fitted in the gas passage just above the facing to which the heater box is attached. A union for a lead to a depression gauge may be substituted for this plug if and when required. The same fourteen studs which retain the fan induction casing to the engine body also retain the rear cover to the fan induction casing. A dowel peg fitted to the rear face of the fan induction casing ensures the correct assembly of the rear cover.

Engine bearer

42. The engine bearer is a dished steel pressing and is attached by twenty-one studs and nuts to the back of the engine body. Its attachment to the airframe is provided for by sixteen bolt holes around its rim. Seven large holes are machined in the bearer and through these the induction pipes and high tension cables pass to the cylinder heads. The engine bearer is cosletised to prevent rust and is never detached from the engine body unless one of the two components is faulty.

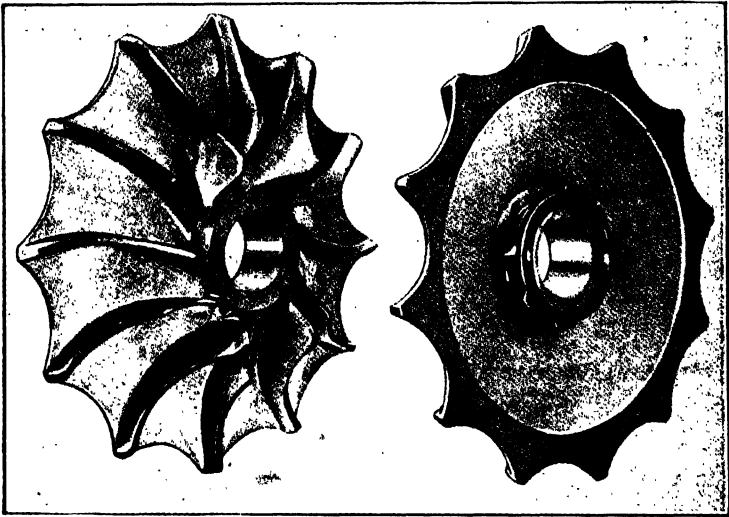


FIG. 18. Fan.

Fan

43. A twelve-bladed fan is mounted on the crankshaft immediately behind the rear main bearing. It is of the shape shown in fig. 18 and is used to improve the distribution of the mixture to the cylinders. It is keyed to the end of the crankshaft, upon which it is retained by a cone-headed nut screwed into the bore of the shaft. The profile of the blades is shaped to suit the contour of the curved surface of the rear cover. The clearance between the front face of the fan and the closed end of the fan induction casing may be adjusted by shims interposed between the end of the fan boss and the shroud washer of the rear main bearing. A phosphor-bronze gland maintains an oil-tight joint between the hub of the fan and the rear face of the housing for the outer race of the rear main bearing.

44. The gland takes the form of a sleeve which is mounted on the hub of the fan and which is forced into contact with the back of the bearing housing by four coil springs. The springs are mounted in sockets drilled in both the front face of the fan and the back of the gland. Two pegs fitted in the fan engage sockets drilled in the gland and thus prevent rotation of the latter around the fan boss. It is most important that the joint between the fan and bearing housing should be maintained oil-tight, in order to avoid serious leakage of oil.

45. A fan that is worn in the keyway is reconditioned by the makers by boring out the worn hub and screwing in a steel hub. The latter is prevented from unscrewing by two set-bolts screwed through its flange into the hub.

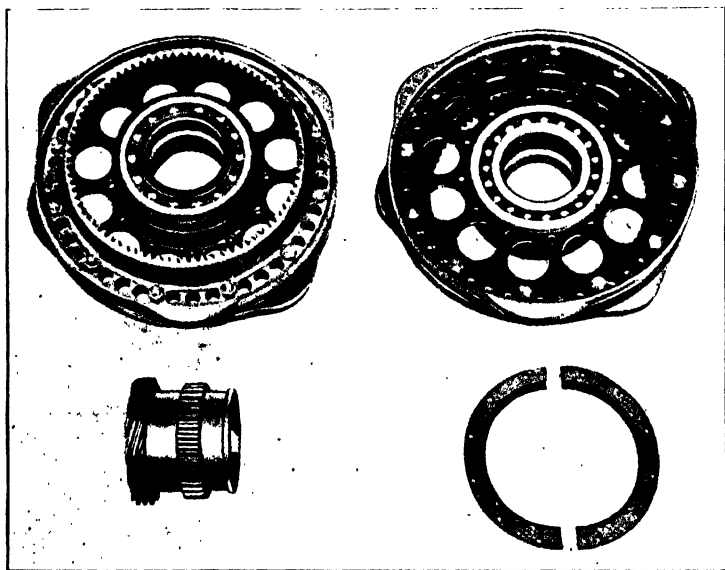


FIG. 19. Cam drum and driving sleeve.

Valve cam gear

46. A single cam ring operates the inlet and exhaust valves of all cylinders through separate push rods and tappets. There are two rows of three equally spaced cams around the ring, the front row operating all the inlet valves and the rear row all the exhaust valves. The ring is mounted upon a component known as the cam bearer, and has an internally toothed gear, or annulus, bolted to its front face. The three parts, when assembled, form a unit known as the cam drum.

The cam drum, crankshaft driving sleeve and halved ring plate are shown in fig. 19. The cam bearer houses the two bearings upon which the unit is mounted, that at the rear being a two-row universal ball bearing and at the front a single-row journal ball bearing. A halved ring plate bolted to the rear face of the cam bearer locates the outer race of the universal bearing in its housing, whilst the outer race of the journal bearing can float axially. The inner races of the two bearings are separated by a distance piece mounted on the crankshaft.

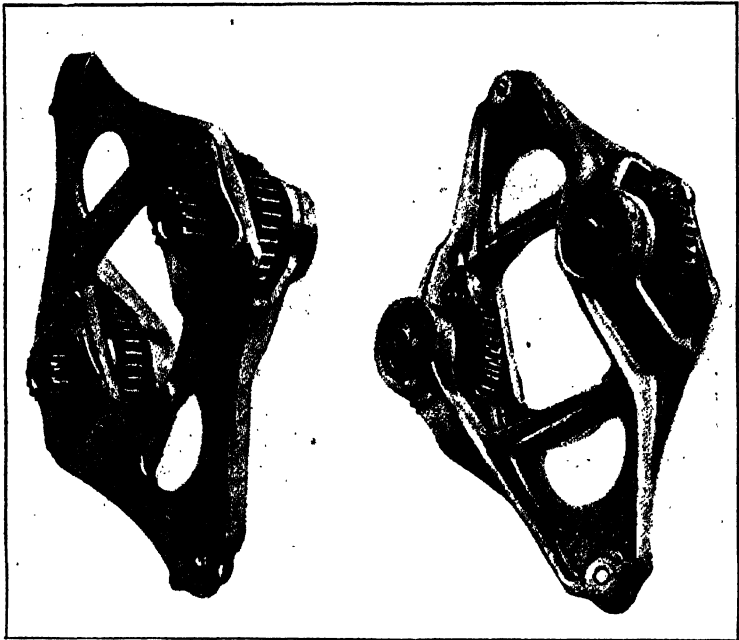


FIG. 20. Timing bracket.

47. The cam drum is driven through two compound gear wheels carried in a frame, known as the timing bracket, and illustrated in fig. 20. This bracket is attached to studded facings provided for it in the engine body between the inner and outer sockets of an opposite pair of tappet guides. As may be seen from fig. 21, the pinion portions of the compound gear wheels are integral with their spindles, whilst the gear wheels are detachable and keyed to the spindles. The latter are mounted in roller bearings between the pinions and gear wheels and on two-row universal ball bearings in front of the gear wheels. The inner races of the roller bearings are held

up against the front ends of the pinions by the rear ends of the gear wheels, whilst the latter are retained by heavy distance pieces fitted to the spindles between the gear wheels and the inner races of the universal bearings. Ring nuts screwed and split-pinned to the front ends of the spindles retain the inner races of the universal bearings in position. The outer races of both the roller and universal bearings are located positively in the timing bracket, the former by plates secured by nuts and bolts to the backs of their housings and the latter by ring nuts screwed into the front ends of their housings.

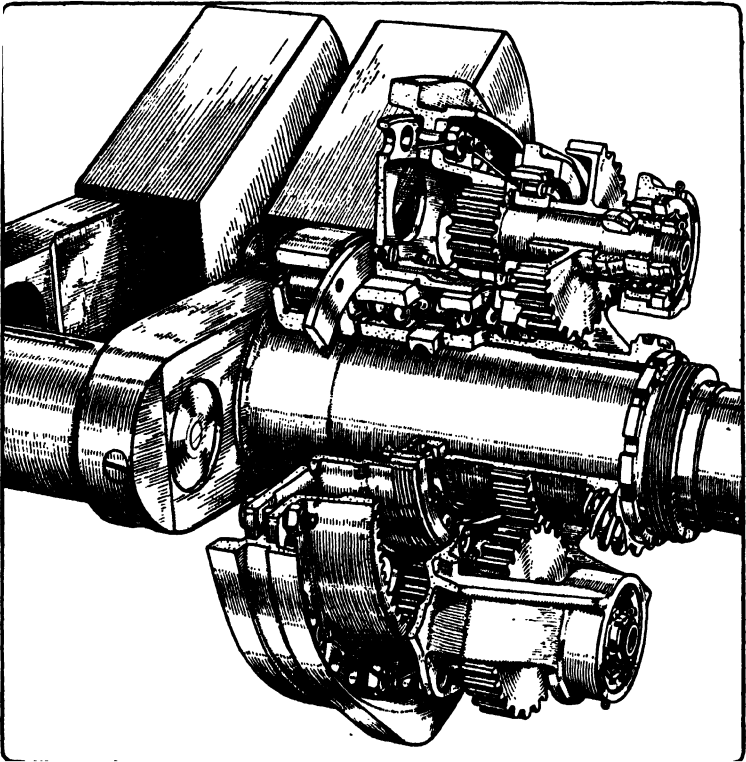


FIG. 21. Valve cam gear.

48. The pinion ends of the compound gear wheels mesh with the annulus of the cam drum, as shown in fig. 22, whilst the gear wheel ends mesh with a ring of spur gear teeth around a cylindrical component keyed to the crankshaft. This component, which is known as the driving sleeve, also has a ring of skew gear teeth machined around its front end for the drive to the oil pump.

49. Both the spur gear portion of the driving sleeve and the larger wheels of the compound gear wheels have 35 teeth, whilst the pinions and the cam drum annulus are machined with 14 and 84 teeth respectively. It will be seen, therefore, from fig. 22, that the cam drum is driven at one-sixth crankshaft speed in the opposite direction of rotation to that of the crankshaft.

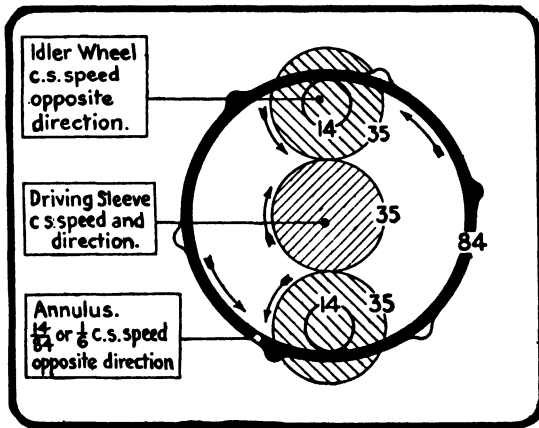


FIG. 22. Cam drum drive (looking from front of engine).

Tappets and tappet guides

50. The tappets which operate the push rods of each cylinder are mounted one behind the other in guides common to each pair, the inlet valve tappet being mounted to the front. The guides are accommodated in seven equally-spaced sockets formed around the front end of the engine body. Each tappet (fig. 23) consists of a cylindrical shank forked at its inner end for the accommodation of a flat-faced roller and bored from the same end for the major portion of its length. It is machined with a hemispherical recess at its outer end for the accommodation of the end of a push rod. Four oil-retaining grooves are machined around the body of the tappet to prevent oil leakage from its guide. A circlip sprung into a groove at the outer end of each tappet prevents it from falling through the guide during certain stages of the erection and dismantling of the engine. The tappet rollers rotate about solid steel pins which float in sockets in the forked ends of the tappets. The pins are each machined with a deep helical oil groove.

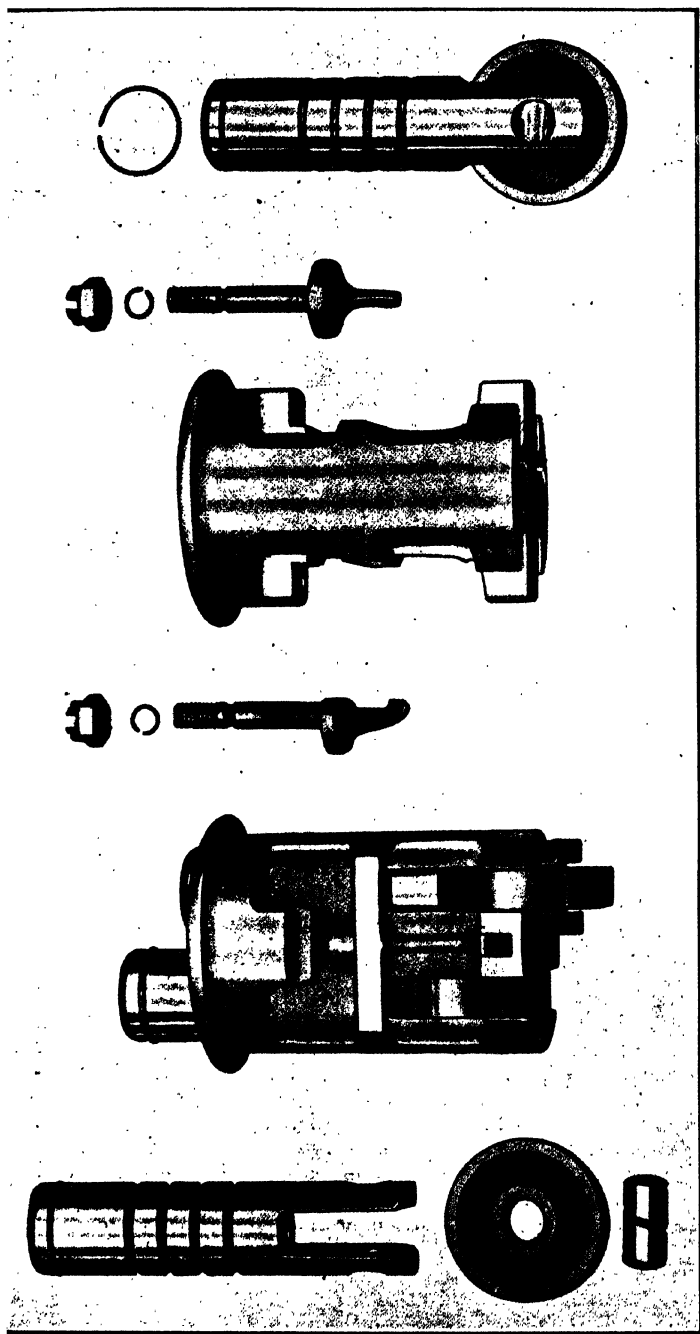


FIG. 23. Tappets and guides.

51. The tappet guides are made from aluminium castings and have bodies cylindrical in form provided with a flange around their outer ends. The flange is accommodated in a recess around the outer end of the socket for the guide in the engine body, and is retained by two bolts, which are accommodated in holes drilled in the guides but not in the engine body. The holes are sufficiently close to the sides of the guides for the heads at the inner ends of the bolts to project beyond the cylindrical bodies of the guides and be accommodated in sockets machined in the interior of the engine body. This construction effectively prevents rotation of the guides in their sockets. Half the head of each bolt is cut away to permit the bolts to be given a half turn and the guides withdrawn with both bolts in position. A hook-like extension beyond the head of the bolt bears on the side of the guide and prevents the bolt from bending due to the off-set loading on the halved head. Slots are machined in the portion of the base of the tappet guide which projects between the tappet rollers; these slots are provided to clear the hooked ends of the bolts when the latter are being inserted.

52. Besides retaining the guides in the engine body, the bolts also retain the inner portion of a cover for the push rods (*see* para. 56) to the outer end of the guide. In order to prevent the bolt from falling into the engine body when the retaining nut is removed, the bolt is grooved to receive a circlip between the outer end of the tappet guide and the base of the push rod cover. Each tappet guide is stamped with the number of the cylinder which it serves.

Push rods

53. The push rods, which are not adjustable, are built-up of lengths of steel tubing into which steel end-pieces are soldered. The outer end-piece has a flat case-hardened end to bear on the thrust pad carried in the end of the rocker, whilst the inner end-piece has a hemispherical end to mate with the domed socket in the outer end of the tappet. The outer end of the push rod body is swaged down to a taper a short distance below the point at which the outer end-piece is fitted. The taper forms the mounting for a sleeve which acts as an anchorage for a coil spring. This spring, by bearing against a retainer fitted in the outer end of the push rod cover tube, retains the cover tube in contact with the inner face of the rocker cover and the inner end of the push rod in contact with the tappet (*see* fig. 24). All push rods are marked for the cylinder and valve to which they are to be fitted, the marked being stamped on the inner end of the tubular body.

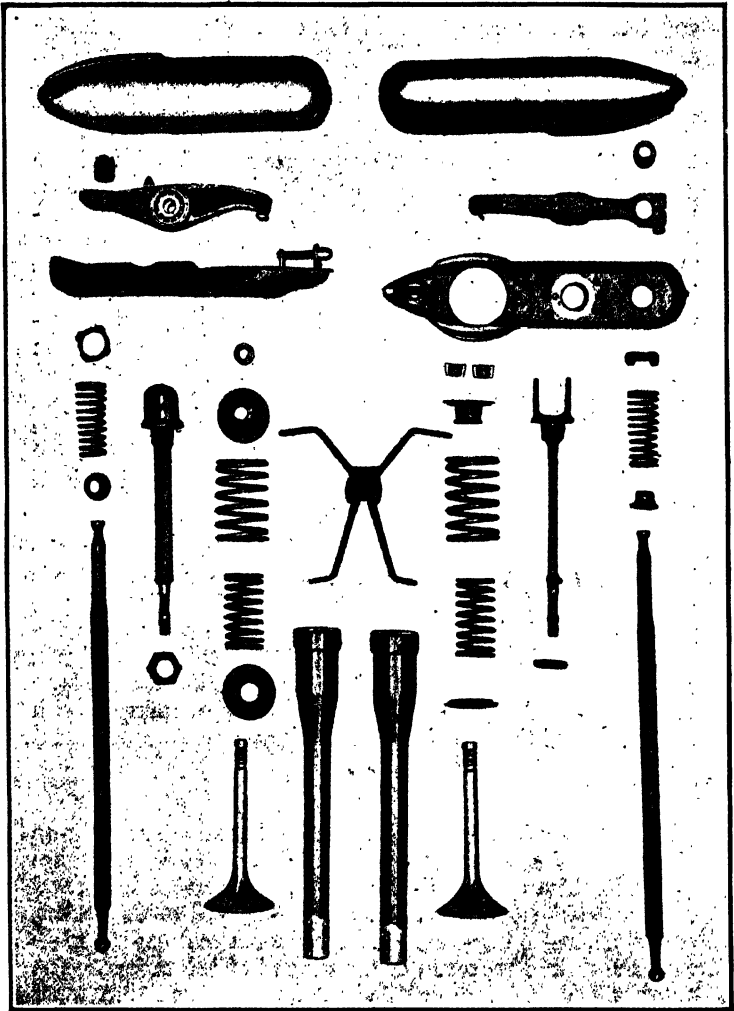


FIG. 25. Push rod covers and valve gear.

Push rod covers

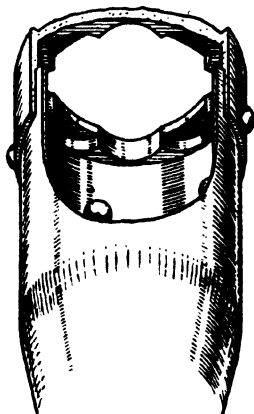
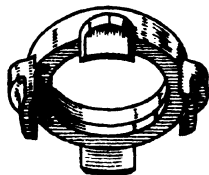
54. The push rod covers each comprise three components, the push rod cover tube, the cover tube bracket, and the spring retainer, all of which are illustrated in figs. 24 and 25.

55. The push rod cover tubes are lengths of aluminium tubing having their outer ends swaged to the shape shown in fig. 24. A cap is riveted to the outer end of each tube to

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BRACKET FOR
PUSH ROD COVERS.



PUSH ROD COVER - OUTER
END AND SPRING RETAINER.

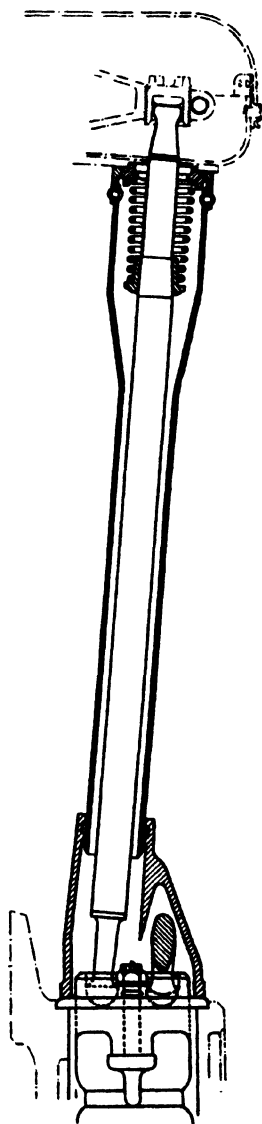


FIG. 24. ARRANGEMENT OF ENCLOSED PUSH ROD AND COVER

bear on the inner face of the rocker cover stiffening plate and to locate a spring retainer against which the outer end of the push rod spring bears. The location of the retainer by the cap is effected by an internal lip around the outer end of the cap. Four notches are cut in this lip to permit the entry of a like number of dogs which project from around the retainer. These dogs, after the washer has been inserted into the cap and given a part turn, are received in four notches milled in the under face of the lip. The cover tubes for inlet and exhaust push rods are identical, but as the caps differ in the inclination of their outer ends with respect to the axes of the tubes, the assemblies are marked F. I. or F. E. on the side of the cap of each tube.

56. The brackets in which the ends of each pair of push rod covers are received are magnesium alloy castings of the shape shown in fig. 24. A felt oil-retaining ring is fitted in a groove near the outer end of the socket for each tube to prevent oil leakage at that point. The brackets are drawn up to the outer ends of the tappet guides by the bolts which retain the guides in the engine body.

Magneto drive shaft

57. The two magnetos are driven from a bevel wheel mounted on serrations machined at the end of a shaft which is driven from the rear end of the crankshaft. The front end of the shaft is splined and is engaged in the bore of the splined plug fitted in the end of the crankshaft. One of the splines on the shaft is pegged and one of those in the plug is of double breadth. The shaft, therefore, can be engaged in one position only with respect to the crankshaft.

58. The driving bevel wheel abuts against a shoulder turned around the shaft. The shank at the rear end of the wheel provides the mounting for the inner race of the single-row journal ball bearing in which the rear end of the shaft is steadied. The inner race of the bearing abuts against a pack of shims fitted to the rear of a shoulder formed around the shank of the bevel wheel. Its rear end projects beyond the end of the shank of the bevel wheel upon which it is retained by a claw mounted on the serrated end of the shaft. This claw, which is shown in fig. 26, is engaged by a similar claw when the hand starter gear is being used.

59. A ring nut, locked by a tab washer, retains the claw on the shaft, and a second pack of shims is interposed between the shank of the claw and the inner race of the bearing. The outer race of the bearing is accommodated in a housing fitted to the rear face of the extension of the rear cover. The same studs which retain this housing to the rear cover

also retain the starter gear. The outer race of the bearing is located axially in its housing between an internal lip formed around its front end and a ring sprung into a groove machined towards its rear end. The pack of shims interposed between the inner race of the bearing and the shoulder around the bevel wheel provides a means of adjustment of the depth of mesh of the driving bevel wheel with the magneto bevel wheels. The pack of shims between the inner race of the bearing and the shank of the claw provides a means of adjustment of the clearance between that claw and its fellow in the starter gear.

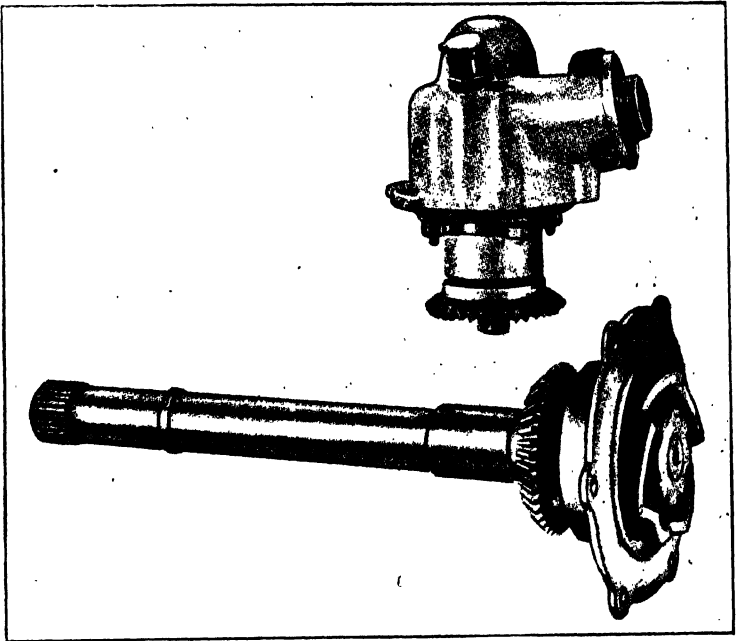


FIG. 26. Magneto drive shaft and engine speed indicator drive unit.

Engine speed indicator drive unit

60. The engine speed indicator drive unit is mounted on the upper face of the extension at the back of the rear cover, and obtains its drive from the bevel wheel of the magneto drive shaft. The unit is built into an aluminium casing and comprises a driving and a driven shaft together with a steel bearing housing and the necessary bearings. The driving shaft has a bevel wheel keyed to its lower end and retained in position by a nut split-pinned to the end of the

shaft. The bevel wheel retains the inner race of a two-row universal ball bearing against a shoulder machined around the shaft and is meshed with the bevel wheel of the magneto drive shaft. The outer race of the bearing is accommodated in a steel housing. It is located axially between a shoulder machined in the bore of the housing and a ring sprung into a groove turned around the mouth of the housing.

61. A worm is keyed toward the upper end of the shaft and abuts against a shoulder machined around the shaft. It is retained against the shoulder by the inner race of a single-row journal ball bearing mounted on the shaft above it and secured in place by a washer, nut, and split pin. A spigoted joint is made between the bearing housing and the casing, and four studs fitted to the casing retain the two components together. These studs pass through a flange formed around the bearing housing and are fitted with nuts and tab washers. A sleeve is formed at the upper end of the bearing housing. It is carried up into the mouth of the worm and provides a baffle by which oil is retained in the casing level with the lower end of the worm. A worm wheel is machined at the inner end of the driven shaft and is engaged by the worm of the driving shaft. A flat is formed in the bore of the shaft in order to transmit the drive to the flexible drive for the engine speed indicator. The shaft is borne in a long phosphor-bronze bush, the outer end of which is flanged for its attachment to the casing. The flange is also provided with a union for the attachment of the union nut of the casing of the flexible drive.

62. The thrust of the driven shaft is absorbed by a phosphor bronze plug let into the wall of the casing co-axial with the driven shaft. A case-hardened plug is let into the end of the driven shaft. The bevel wheel, worm, and worm wheel provide a final drive at a speed of one-quarter crankshaft speed. A pack of shims, fitted between the base of the engine speed indicator drive unit and its seating on the rear cover, provides a means of adjustment of the depth of mesh of the driving shaft bevel wheel with the magneto drive shaft bevel wheel. An oil filler cup is fitted at the upper end of the casing of the unit. Oil poured through this cup fills the casing to the level of the top of the sleeve around the drive shaft before it can find its way into the sump at the back of the rear cover. Since the oil, when poured into the engine speed indicator drive casing, would take some little time to find its way down the bore of the sleeve around the drive shaft, two alternative passages are provided for it. These are drilled in lugs cast in the interior of the casing and register with holes drilled in the flange around the bearing housing.

Hand starter gear

63. The hand starter gear provides a means of turning the crankshaft of the engine through the claw fitted to the magneto drive shaft. It comprises a claw which obtains its drive from the bore of a large worm wheel ; the latter is in turn driven by a worm shaft to either end of which a starting handle may be fitted. Provision is made for throwing and retaining the claw of the gear out of engagement with that of the magneto drive shaft as soon as the engine starts, or should a back-fire occur. Any tendency for a reversed drive to be transmitted through the worm shaft is avoided by a ratchet gear fitted between the worm shaft and the casing of the unit. When the engine is being started, the claw of the starter gear is retained under spring pressure in engagement with the claw on the magneto drive shaft.

64. As will be seen from figs. 27 and 29, the various components of the starter gear are housed in or attached to a two-piece aluminium casing which is bolted to the back of the rear cover. A large worm wheel occupies the greater part of the interior of the casing and is supported in a cup and cone ball bearing and a roller bearing. The cup and cone bearing is fitted at the front end of the worm wheel and is of the uncaged type. Its inner race is formed on the shank of the worm wheel. Its outer race is L-sectioned, and is accommodated in a housing formed in the front end of the casing. The roller bearing is mounted on the shank at the back of the worm wheel, its inner race being formed by the shank of the wheel itself. Its outer race is an L-sectioned steel ring accommodated in a housing formed in the rear portion of the casing. The worm wheel is located axially between the vertical faces of the outer races of its bearings by the ring of balls and the cage in which the rollers are mounted. The worm wheel is driven from a worm shaft housed in the lower end of the front portion of the starter casing.

65. The worm shaft is supported in two phosphor bronze bearings. The right-hand bearing (as viewed from the rear of the unit) is a flanged bush of the open-ended type and is pressed into its housing from the interior of the casing. The bearing at the left-hand end of the shaft is of a more elaborate design. Its external diameter is such that the worm shaft may be entered into the starter casing through its housing. At its inner end the bearing provides the anchorage for the outermost of two thrust rings of a ball bearing through which the thrust of the worm shaft is transmitted to the casing. The inner ring abuts against a shoulder formed around the worm shaft and the thrust from the shaft is absorbed by the two studs which retain the flange of the bearing

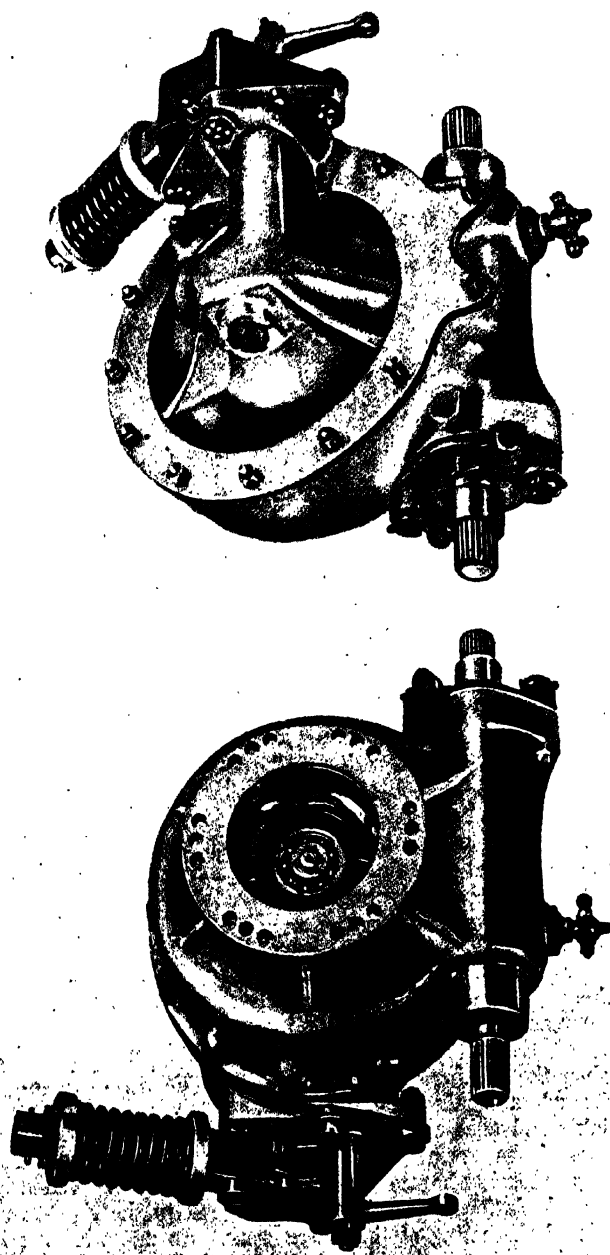


FIG. 27. Hand starter gear.

to the casing. These studs are locked by means of grub screws screwed into the casing.

66. Special nuts having cylindrical shanks beneath their hexagonal heads are fitted to the studs which retain the bearing in its housing. Pawls are fitted around the shanks of these nuts and engage a ratchet wheel pinned to the worm shaft immediately outside the bearing. The pawls are retained in engagement with the ratchet wheel by small coil springs, the outer ends of which are accommodated in sockets formed on the bearing flange as shown in fig. 27. The ends of the worm shaft, where they project beyond the right-hand bearing and the shank of the ratchet wheel, are splined for the engagement of a cranked starting handle.

67. The rear end of the bore of the worm wheel is splined to transmit the drive to the starter claw, the shank of which is passed through it. The shank of the claw is entered into the bore of the worm wheel through the front end of the starter casing. The head of the claw is housed in a flanged extension of the casing. The claw is centred in the bore of the worm wheel by the front end of its shank, which is not serrated, and which is carried in the front end of the shank of the worm wheel, which also is not serrated. The claw is advanced towards or withdrawn from the claw at the end of the magneto drive shaft by a small connecting rod or operating link. This is a short rod riveted at its front end to the inner race of a two-row universal ball bearing and formed at its rear end with a socket for the accommodation of a crankpin at the end of a rocking shaft. The outer race of the universal bearing is carried in the front end of the starter claw. It is located axially between a shoulder formed in the bore of the claw and a ring sprung into a groove machined around the mouth of its bore.

68. As stated above, the rear end of the operating link is engaged by a crankpin at the inner end of a rocking shaft. The rocking shaft is a light spindle mounted transversely in the rear portion of the starter gear casing parallel to, but above, the worm shaft. It will be seen from fig. 28 that when the rocking shaft is rotated backwards and forwards through a small angle, its crankpin causes the operating link to advance and withdraw the turning claw through the bore of the worm wheel. The rocking shaft is borne in a long phosphor-bronze standard attached by a peculiarly shaped platform formed at its outer end to the right-hand side of the casing of the starter gear. An operating lug is keyed to that end of the rocking spindle which projects beyond the outer end of its bearing standard and is retained

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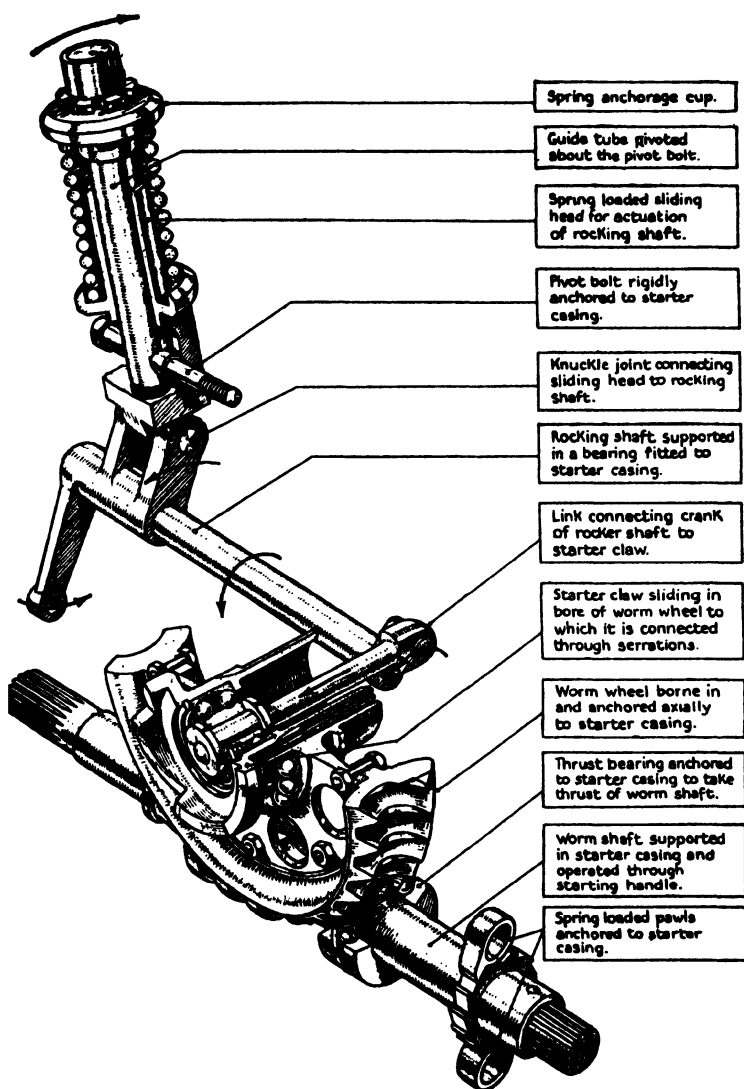


FIG. 28. OPERATION OF HAND STARTER GEAR

in position by a nut. The lug is provided on its upper surface with two arms which form a knuckle joint with a spring-loaded sliding head. A control lever is formed on its lower surface.

69. The sliding head, which is of aluminium, is mounted upon a steel guide tube pivoted about a bolt taken through a bracket formed integrally with the platform at the end of the rocking shaft bearing standard. The bolt about which the guide tube is pivoted also passes through the lower end of the sliding head. The sides of the latter component are slotted where the bolt passes through it and so permit it to have a short axial travel up and down the tube. When the operating lug on the rocking shaft is connected through the knuckle joint to the lower end of the sliding head, rotation of the rocking shaft will cause the sliding head to travel up and down the guide tube.

70. The sliding head reaches the highest point of its travel on the guide tube when the rocking shaft is turned so that the centre line through the knuckle joint lies in the plane through the centre lines of the rocking shaft and the bolt about which the guide tube is pivoted. When the rocking shaft is in this position it will have caused the sliding head to have swung the guide tube about the pivot bolt so that its axis also lies in the plane through the centre line of the rocking shaft and pivot bolt. Any rotational movement of the rocking shaft to a position other than that detailed above will cause the sliding head to travel towards the base of the guide tube, which will swing about its pivot bolt into some other position. The operating lug is so positioned on the rocking shaft that when the latter is turned in an anti-clockwise direction (when viewed from its operated end) past the top dead centre position described above, the operating link withdraws the turning claw into the bore of the worm wheel. The reverse occurs when the rocking shaft is turned in the opposite direction.

71. The design of the gear is such that when the rocking shaft is turned through 13° in an anti-clockwise direction past the T.D.C. position the turning claw is fully withdrawn from engagement with that at the end of the magneto drive shaft. When the rocking shaft is turned through 28° in a clockwise direction past the T.D.C. position the turning claw is brought into full engagement with the claw on the engine. With the rocking shaft in its T.D.C. position, the turning claw is engaged to about one-quarter of its depth with the claw on the engine. When the rocking shaft is turned from the "claw fully withdrawn" position to the "claw fully engaged" position, or vice versa, the sliding head first travels upwards over the guide tube, reaches its highest point and then descends to a lower position.

72. The rocking shaft is retained in the "engaged" or "free" positions by a strong coil spring fitted around the guide tube, and anchored at its upper end to a spring cup which abuts against a nut screwed to the end of the tube. At its lower end the spring engages a shoulder formed around the centre portion of the sliding head. The spring tends to retain the sliding head at its lowest position on the guide tube.

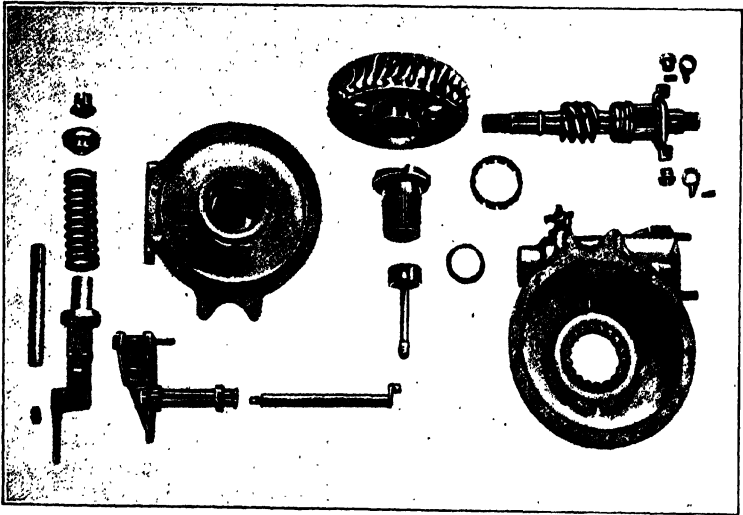


FIG. 29. Components of hand starter gear.

73. The operation of the starter gear is as follows. The operating lever at the end of the rocking shaft is actuated, by means of a cable or other control, so as to rotate the shaft in a clockwise direction. This causes the sliding head to commence to travel upwards over the guide tube, thus compressing the spring. As soon as it passes its T.D.C. position the spring commences to return it to a lower position on the guide tube. The sliding head being thus forcibly returned down the guide tube causes the rocking shaft to throw and retain the starter claw in forced engagement with the claw on the engine. The turning handle may now be employed and the engine turned. As soon as the engine is started, the claw at the end of the magneto drive shaft over-runs the starter claw. The claw on the engine when over-running the starter claw forces the latter backwards into the bore of the worm wheel. As the starter claw is thus returned, it causes the rocking shaft to turn in an anti-clockwise direction and the sliding head to travel up the guide tube against the pressure of its spring. When the two claws are about three-quarters out of engagement the rocking

shaft passes its T.D.C. position. When this occurs the spring forces the sliding head home and thus causes the starter claw to be fully withdrawn.

74. On reference to fig. 28 it will be noticed that the driving faces of the teeth on the starter claw have a slight lead in an opposite direction to that of their backs. The teeth of the claw at the end of the magneto drive shaft are treated similarly. This causes the teeth of the claws to tend to ride out of engagement when the crankshaft is being turned. This tendency is counteracted by the spring pressure holding the two claws in engagement. This pressure, however, is not strong enough to hold the claws in contact should a back-fire occur. On the occurrence of a back-fire the two claws commence to ride out of engagement and the starter claw is automatically withdrawn as soon as the two claws are three-quarters disengaged. The ratchet gear fitted to the worm shaft is provided to guard against that component being turned through any reversal of drive that might occur.

Ignition system

75. Two B.T.H. magnetos, type S.C.7-1, driven at $\frac{7}{8}$ engine speed, are each spigoted and secured by three studs and nuts to the port and starboard sides of the extension of the rear cover. Each magneto is driven from the magneto drive shaft through a bevel wheel keyed to its spindle, the bevel wheel being machined with five keyways and 48 teeth. The purpose of these keyways is to provide a vernier adjustment of the magneto spindle with respect to the magneto drive shaft. The bevel wheel fitted to the magneto drive shaft has 42 teeth. This system of gearing and keying permits a minimum correction of $\frac{1}{2}^\circ$ to be made to the timing.

76. An extractor for removing the magneto bevel wheel can be screwed into a thread machined around the interior of the lip from which the teeth radiate. An oil thrower ring is mounted on the shank of the bevel wheel. Adjustment of the depth of mesh of the bevel wheels is obtained by packs of shims fitted between the mounting flanges and the sides of the rear cover. Fixed timing is employed on the engine, the contact breaker cover being locked to the magneto body. The starboard magneto serves the sparking plugs beneath the inlet valves of all cylinders.

77. The ignition cables are of the metal-braided type and are fitted with standard sleeved end connections as described in A.P. 1464, Vol. 1, Part 3, Sect. 7, Chap. 3. At the magneto end of each cable, a small insulating sleeve, having the number of the cylinder which it serves engraved on it, is passed over

the cable. Those passed over the port magneto cables are coloured black, those on the starboard cables red. The sleeves at the sparking plug ends are marked and coloured similarly.

78. The cables are attached to the magneto distributors by having the lips of their sleeves clipped between the face of the distributor shield and the clamping plate. After leaving the magnetos the cables are taken upwards over the magnetos and are clipped together with spring steel clips as shown in fig. 30. They are then led to the induction pipes serving their respective cylinders. Each pair of cables is fixed by spring steel clips and die-cast aluminium clamping blocks to the inner and outer ends of their respective induction pipes. Where the cables cross the cylinder heads they are clipped between aluminium and fibre clamps secured to the heads by studs and nuts. The fibre clamps are undermost to insulate the cables from the heat of the heads. The cables are attached to the sparking plugs by means of A.G.S. terminal adaptors.

79. Bonding of the ignition cables is effected by connecting with two lengths of copper wire, the six clips which bind the cables together after they leave the magnetos, to two of the nuts retaining the hand starter gear to the rear cover.

Induction system

80. The Zenith carburettor, type 65 G-1, is attached to a heater box mounted at the lower end of the elbow-shaped passage formed in the rear cover. Hot oil is circulated through the jacket of the heater box by the scavenge pump. On entering the fan induction casing the mixture is distributed to the induction pipes by the fan, which has no appreciable super-charging effect. A priming ring is attached to the rear cover and feeds six radial pipes which inject fuel into the inlet ports of all cylinders except No. 1.

Carburettor

81. The carburettor, which is illustrated in figs. 31 and 32, has a single float chamber, choke tube and throttle. The carburettor body (2) (fig. 32) is formed by a single aluminium alloy casting and has bolted to its under surface a cast aluminium air intake junction box. The float chamber is cast on the left-hand side of the body (when viewed from the rear) and houses a spun brass float (31) of the spherical type. The float operates a stainless steel needle valve (24) housed in an annexe to the float chamber formed on the rear face of the latter. Operation of the needle valve is effected by the forked end of a bracket riveted and soldered to the float. The float is pivoted about a pin (30) which passes through the bracket and is carried in bosses formed on the walls of the float

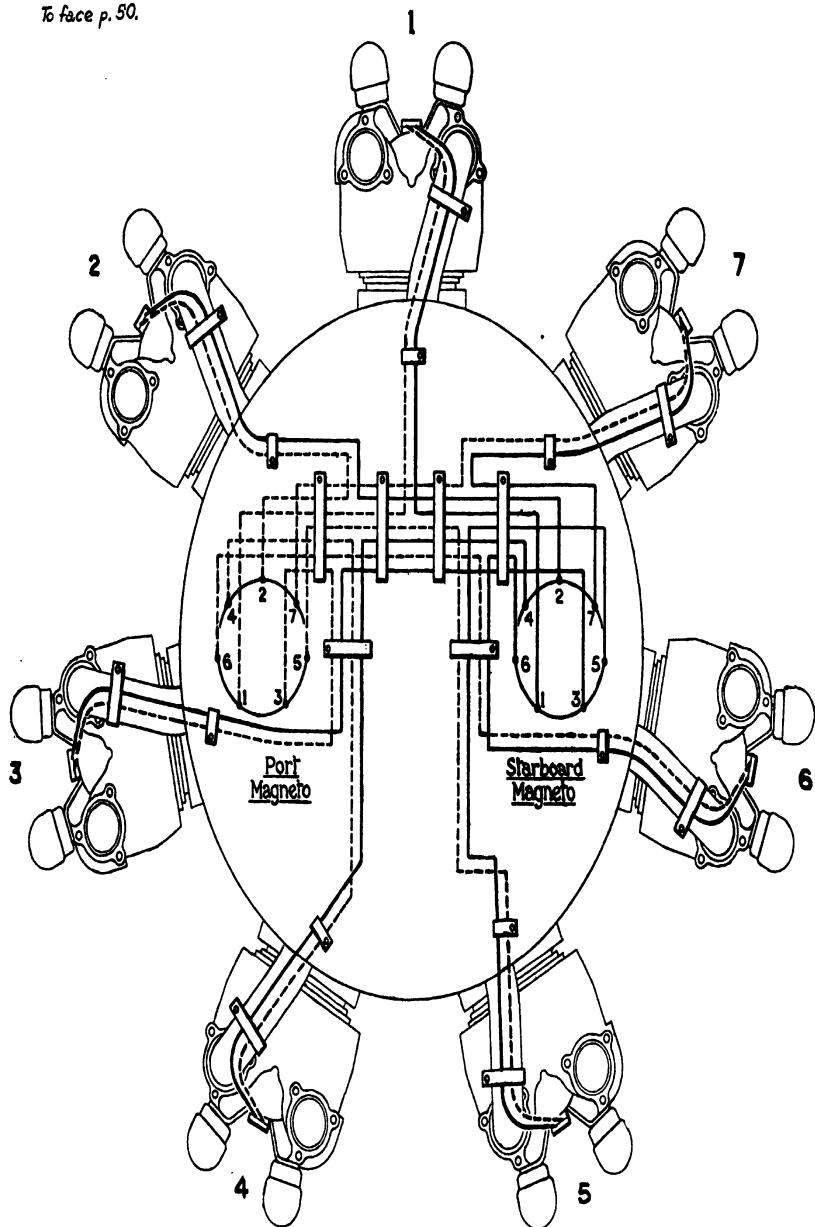


FIG.30. IGNITION WIRING DIAGRAM

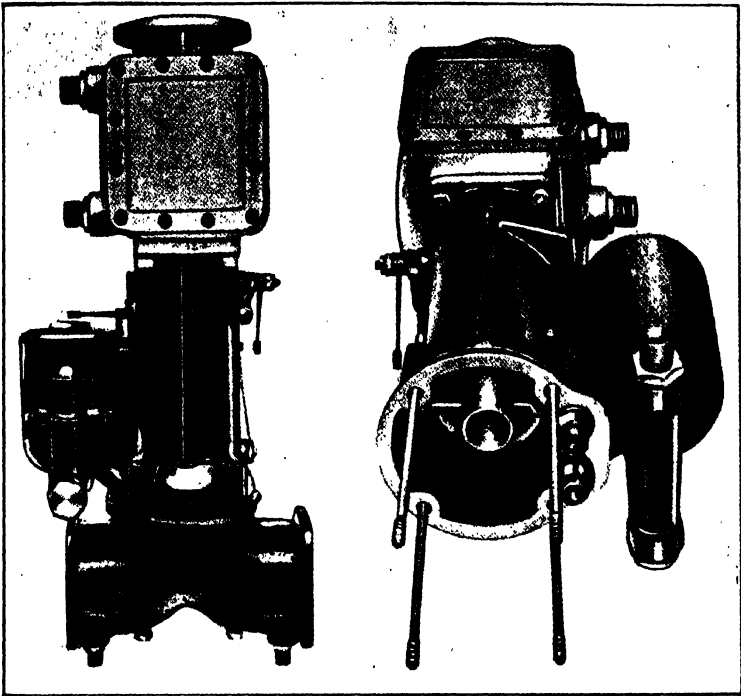


FIG. 31. Carburettor and heater box.

chamber. One end of this pin is soldered into a brass plug which is screwed into one of the bosses mentioned above, the other end being accommodated in the bore of a similar plug (46) screwed into the second boss. The mouth of the float chamber is closed by a gun-metal cover (20) which is screwed in position, a fibre washer (19) being inserted between the float chamber and cover. The latter is secured by a locking plate (18) and circlip (17), the locking plate having two prongs which straddle the mixture control valve (10). The stainless steel needle valve seat (27) is screwed into the base of the annexe to the float chamber and is locked by means of a locking plate (25) and circlip (29). A fibre washer (48) is interposed between the seat and the base of the annexe. Fuel is supplied to the throat of the seat by a large passage (28) cast underneath the float chamber. A stainless steel union (38), locked with a copper tab-washer (47), is fitted in one end of the passage, the other end being blanked off by means of a brass plug (26) which is also locked with a tab-washer.

82. The portion of the float chamber above the fuel level communicates with the base of the choke tube (1) by a vertical duct formed between the outer diameter of the choke tube and its housing. A short duct (8) puts the float chamber into communication with the vertical duct, and a small gauze filter (7) covers the outer end of the latter. The gauze is soldered to a corrugated sheet metal frame which is clipped between the outer diameter of the choke tube and the wall of its housing. A vertical jet well is formed on each side of the float chamber, between it and the choke tube housing.

83. The foremost of these wells accommodates the slow-running jet assembly and compensating jet (35). The slow-running jet is virtually a small self-contained carburettor which supplies a correctly proportioned mixture for slow-running. It consists of a brass tube, known as the slow-running jet outer tube (23), into the lower end of which is screwed a tubular extension (34) having a jet formed at its upper end. This jet is submerged for about five-sixths of its length by the fuel in the jet well. The top of the slow-running jet outer tube is threaded internally to receive an inner tube (14) provided with a knurled head and lock nut (59) at its upper end. The lower end of the inner tube almost meets the conical upper end of the slow-running jet, the small gap between the two serving as an air choke for the jet. Adjustment of the gap by means of the knurled head varies the strength of the mixture by varying the velocity of the air through the gap. Thus anti-clockwise rotation of the head weakens the mixture by increasing the gap and so reducing the velocity of the air around the jet. The slow-running jet outer tube is drilled with small holes (13) to admit air from the float chamber by a short duct (12) between the top of the float chamber and the jet well. On passing through the gap between the inner tube and jet the air mixes with the fuel, and the mixture passes up the bore of the inner tube. It flows through a hole in the upper end of the outer tube into a short horizontal duct in the carburettor body, whence it is supplied to the bore of the choke tube housing by a sloping duct (6) drilled in an external web. The mouth of the duct in the choke tube housing is covered by the throttle (3) when the latter is closed.

84. Below the slow-running jet assembly is a horizontal duct (36) connecting the slow-running and compensating jet well to the main jet well. The bore of the duct is decreased at the end nearest the main jet well. Below this duct the compensating jet (35) is screwed into the bore of the jet well. The jet is formed in the bore of a brass plug which is screwed into its socket from the lower end of the well. A fibre washer (51) interposed between a shoulder around the

plug and a shoulder in the well makes the joint. A sloping duct (33) to supply fuel to the well is drilled from the lower end of the float chamber to break into the well below the compensating jet. A brass plug (52) and a fibre washer (62) seal the lower end of the well.

85. The second jet well does not extend the full depth of the float chamber, as does that described above, but breaks into the base of the housing for the mixture control valve (10). The housing is offset from the jet well but communicates with the latter. The main jet (39) is screwed into the lower end of the jet well at about the same level as the compensating jet. The main jet is of the shrouded type, the actual jet being formed at the base of a guard tube. The lower end of the tube is of greater diameter than the upper portion and is threaded for engagement with its socket in the jet well. As in the case of the compensating jet, a fibre washer (50) interposed between shoulders formed on the jet and in the jet well makes the joint. The duct (36) from the compensating jet well breaks into the main jet well close to the base of the guard tube of the main jet. A duct (37) from the base of the float chamber breaks into the jet well below the main jet, and the base of the well is sealed by a brass plug (52) and fibre washer (62). This plug is locked with wire to the plug in the base of the slow-running jet well. When the mixture control valve is closed, the air supply to the main jet well is by the small duct (36) connecting the two jet wells. As the compensator jet well contains fuel, the air supplied to the main jet contains a definite proportion of fuel, the amount depending upon the size of the compensator jet.

86. The mixture control valve (10) provides for the admission of air direct into the upper end of the main jet well. The housing for the valve is drilled with a duct (9) which communicates with the portion of the float chamber above the fuel level. The valve is of the barrel type and is bored from its underside for part of its length to form a sleeve in which a slot is machined to register with the duct to the float chamber. When this slot is in registration with the duct to the float chamber, a rectangular port (16) machined in the lower end of the sleeve is brought over the aperture connecting the housing with the main jet well. The barrel is operated through a lever (63) fitted to its upper end and is retained in its housing and restricted in its travel by a stop pin (57) screwed into it. This pin is entered into the wall of the barrel and travels in a slot (61) machined in the wall of the housing. When the barrel is turned so that it seals the duct to the float chamber, the slot machined in its wall registers with an anti-syphoning hole (11) which communicates with the air direct. At a point just below where it breaks

into the mixture control valve housing, the jet well communicates with a duct (44) taken vertically down the side of the choke tube housing. This duct serves the diffuser (41) with mixture.

87. The choke tube (1) is machined from an aluminium alloy casting and is retained in its housing by a setscrew (45). The latter engages a groove around the upper end of the choke tube. The diffuser consists of a brass venturi tube (41) mounted in a bracket (40). A waist machined around the outside of the tube is drilled with twelve holes which communicate with the throat of the tube. An eye formed at one end of the venturi bracket fits around the waist of the tube, thereby forming a circular duct. This duct communicates with the duct from the upper end of the main jet well by a passage drilled in the shank of the bracket. The end of the shank is flanged and spigoted to locate the diffuser in the choke tube housing, whilst a small peg (54) pressed into the flange engages a hole in the housing and so prevents the diffuser from turning. A fibre washer (49) is interposed between the face of the flange and the face at the end of the duct in the housing. The bracket is forced up against the housing by a brass retaining tube (42) screwed into a boss formed in the bell-mouthed end of the housing. The inner end of the tube locates the diffuser by means of a small centring boss machined on the eye of the venturi bracket diametrically opposite to its shank. The retaining tube is prevented from unscrewing by a nut (43) which is locked with brass wire to the setscrew (45) securing the choke tube in its housing.

88. The throttle (3) is of the butterfly type and is mounted upon a spindle (4) to which it is secured by two setscrews (53) spot-soldered in position. The spindle is carried in two flanged brass bushes (5) screwed into bosses on the carburettor body. Each of the bushes is locked by means of two silver steel pegs (55) driven into holes in the bush and body. The edges of the holes in the bushes are peened over to retain the pegs in position. The spindle is operated by a lever (56) attached to it by a castellated nut, the travel of the spindle being restricted by a stop which engages a lug cast on the carburettor body. A grub screw (58) and lock nut fitted to the stop enable the slow-running position of the throttle to be adjusted to fine limits.

89. The upper flange of the carburettor is drilled with four holes for attachment to the heater box. When in position on the engine the carburettor is steadied by a steel bracket secured at one end to the upper ends of the front two studs by which the air intake junction piece is attached. The other end of the bracket is bolted to the engine bearer.

90. When the engine is stationary the fuel level is just below the top of the main and slow-running jets. The compensating jet is submerged. When the engine is running slowly with the throttle almost closed, the delivery duct (6) from the slow-running jet inner tube is subjected to a strong depression owing to the small gap between the throttle and choke tube housing. This depression draws fuel from the slow-running jet together with a quantity of air that is drawn through the gap between the lower end of the slow-running jet inner tube and the nozzle of the jet.

91. As the throttle is opened the depression in the slow-running jet delivery duct decreases and the diffuser commences to operate, fuel being drawn from both the main jet and the compensating jet. At first a large proportion of the fuel is supplied by the compensating jet, but as the throttle is opened further, the supply from the main jet increases. To prevent the mixture from becoming too rich, the main jet fitted is not large enough to supply sufficient fuel. The deficiency is overcome by the compensating jet, which delivers a fuel-air mixture to the main jet well by way of the duct (36) interconnecting the two jet wells. The amount of fuel delivered by the compensating jet remains constant irrespective of the suction in the interconnecting duct because the bore of the latter is much smaller than that of any of the ducts supplying air to the compensating jet well. The compensating jet, therefore, supplies fuel entirely by gravity, and not by suction. Thus, whilst the main jet delivers fuel only, the amount varying with the engine speed, the compensating jet delivers to the main jet well a fuel-air mixture, the amount of fuel remaining constant and the amount of air varying with the engine speed.

92. As previously stated, the mixture control valve provides for the admission of air direct into the upper end of the main jet well. This extra air, besides weakening by dilution the mixture supplied to the diffuser, also decreases the depression in the main jet well and so reduces the amount of fuel passed by the main jet.

Heater box

93. The heater box consists of an aluminium alloy casting and provides an oil-jacketed passage for the mixture between the carburettor and the rear cover. It is flanged at each end, the joint between it and the carburettor being a metal to metal one and that between it and the rear cover being made by an alcumite washer. The front and rear faces of the jacket as cast are open and are subsequently sealed by means of aluminium cover plates which are secured by set-screws; the joints are made with alcumite washers. The

hot oil from the scavenge pump enters the jacket through the lower of the two unions on the right-hand side (when viewed from the rear) and leaves for the lower union on the rear cover through the upper union.

Induction pipes

94. The induction pipes consist of lengths of mild steel tubing shaped as shown in fig. 74 for attachment to the fan induction casing and cylinder inlet ports. Their method of attachment to the fan induction casing is described in para. 39. At their outer ends they are secured by ring nuts to the flanges attached to the inlet ports in the cylinder heads. A small flange is welded to the outer end of each pipe and is engaged by the ring nut, the joint between the induction pipe flange and the inlet port flange being made by a copper and asbestos washer.

Priming system

95. A priming ring, built up from two lengths of small-bore steel tubing, is secured to the rear cover by seven clips fitted beneath the nuts which retain the rear cover to the fan induction casing. From this ring, six branch pipes are taken to small elbows screwed into bosses in the inlet ports. The fuel is atomised before it enters the ports by passing around quick-threaded plugs housed in the bosses. No provision is made for priming No. 1 cylinder owing to the danger of washing oil from the cylinder wall. The boss in the inlet port of this cylinder is therefore sealed with a screwed plug in place of the elbow. The fuel is supplied by a hand-operated pump carried in the aeroplane and is fed to the ring by a tee-piece adjacent to the blanked-off union for a pipe to No. 1 cylinder.

Lubrication system

96. A feed pump and a scavenge pump are employed in the lubrication system of the engine. The feed pump is served direct from the aeroplane oil tank and delivers oil by way of a duct to the pressure filter housed in the front cover (see fig. 33). This filter is so designed that, should it become choked, the pressure of oil moves it back against a spring, allowing unfiltered oil to pass. A pressure relief valve in the oil pump unit puts the delivery side of the feed pump into communication with the intake side of the scavenge pump when the pressure exceeds 85 lb. per sq. in. From the filter the oil is forced through a duct to an annular chamber in which the oil-retaining shanks of the crankshaft rear lock nut and thrust bearing carrier rotate. Oil escaping past the shank of the lock nut lubricates the cam gear, tappets and oil pump driving gears, whilst that escaping past the shank of the

thrust bearing carrier lubricates the components of the thrust assembly. It is prevented from escaping past the front cover thrust plate by an oil-retaining scroll around the shank of the crankshaft front lock nut. From the thrust housing the oil drains back to the front cover through two holes drilled in the housing.

97. Oil in the annular chamber enters the hollow crankshaft through two diametrically opposite holes drilled radially in it. From the bore of the shaft the oil passes through the duct in the crankweb into the bore of the crankpin sealing plug. Oil escaping from the holes in the crankpin sealing plug and crankpin lubricates the master rod, grooves being machined diametrically opposite on the crankpin. Holes drilled in the master rod and bearing supply oil to the hollow wrist pins, as described in para. 14. On escaping from the master rod bearing and wrist pins the oil is atomised by the rotating parts and lubricates the cylinder walls, gudgeon pins and front and rear main bearings. A small duct drilled in the fan induction casing and rear main bearing housing supplies oil to lubricate the fan gland.

98. All oil condensing on the walls of the crankcase assembly drains into the small sump in the base of the engine body. The scavenge pump withdraws it from the sump by an external pipe and scavenge filter, and delivers it by another pipe to the heater box and rear cover, whence it is returned to the tanks. Two breathers act as relief valves in the event of pressure building up inside the crankcase assembly.

99. The magneto bevel wheels and the engine speed indicator drive unit are lubricated from a hand-filled sump in the rear cover. When the level of the oil is at the top of the guard tube of the levelling cock, the teeth of the magneto driving bevel wheel dip into the oil and distribute it to the gears and bearings by splash. When pouring oil into this sump through the filler cap in the casing of the engine speed indicator drive unit, a certain amount of oil is trapped in the latter because the overflow ducts from the casing to the rear cover are near the top of the casing. The small reservoir thus formed lubricates the components of the drive unit. The hand starter gear is also hand-fed, the oil being contained in the wormshaft housing. The wormshaft dips into it and distributes it to the mechanism of the gear.

Oil pump unit

100. The oil pump unit comprises a feed pump, scavenge pump, scavenge pump filter, and pressure relief valve. All the above components are contained in a two-piece aluminium casing. Both pumps are of the meshed pinion type. The

pump casing is split in a horizontal plane between the two pumps. It houses in its upper portion the feed pump and in its lower portion the scavenge pump, scavenge pump filter and pressure relief valve. The driving pinions of both pumps are keyed to a common spindle. The driven pinions float on a common spindle which in turn floats in bushes fitted in the ends of the two pump chambers. From fig. 34 it will be seen that a long standard is cast above the feed pump chamber to house the upper end of the driving spindle. The spindle is supported in this standard in two phosphor-bronze bushes fitted one at its upper end and one in the roof of the pump chamber. A flange machined with four radial oil grooves is formed around the outer end of the upper bush. This flange receives the thrust from a skew gear wheel keyed to a parallel-sided mounting at the upper end of the driving spindle.

101. The lower end of the driving spindle is accommodated in a phosphor-bronze bush fitted in the floor of the scavenge pump chamber. The skew gear wheel mentioned above is meshed with the skew gear pinion around the driving sleeve and is driven at half crankshaft speed. The flange of the wheel is drilled with several holes to allow oil to reach the flange of the upper bush.

102. A shoulder is formed around the driving spindle immediately below the bush in the roof of the feed pump chamber, the upper face of the driving pinion of the feed pump being recessed to take this shoulder. This pinion, which like the remainder is of duralumin, is keyed to the spindle and is separated by a phosphor-bronze D-washer from the driving pinion of the scavenge pump. The end of the driving spindle, where it projects below the scavenge pump pinion, is accommodated in the phosphor-bronze bush let into the floor of the scavenge pump chamber. The driven pinions of the two pumps are mounted freely on a hollow spindle which, as previously stated, floats in bushes mounted in the ends of the two pump chambers. A shoulder is formed near the mid-point of the spindle and is accommodated in the bore of a second D-washer which is of mild steel. The bore of each of the driven pinions has a spiral oil groove machined in it, the groove being fed with oil by radial grooves in both ends of the pinion. These radial grooves run from the roots of the teeth into the ends of the spiral grooves.

103. The scavenge pump pinions can be distinguished from the feed pump pinions by the fact that they are deeper than those of the feed pump. The two portions of the pump casing are secured together face to face, and the two pump chambers sealed one from the other by the two D-washers mentioned above as being fitted around the driving and driven spindles

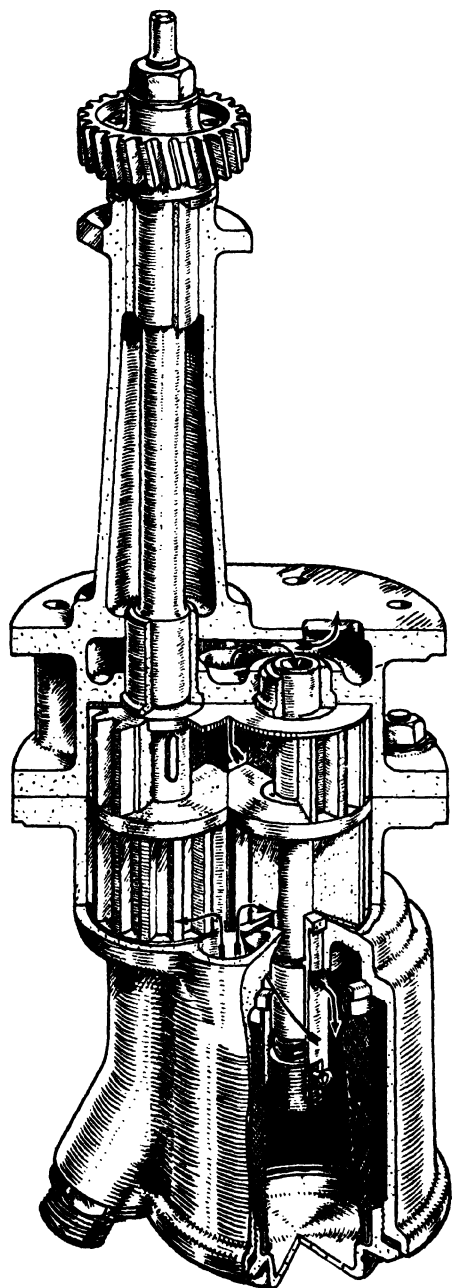


FIG. 34. — OIL PUMP.

between the two sets of pinions. They are accurate fits in the mouths of the two pump chambers and project into each by half their depth. In addition, therefore, to sealing the two chambers one from the other they act as spigots to ensure the correct alignment of the two portions of the pump casing.

104. The oil enters the feed pump through the uppermost of the three unions which project from the sides of the pump unit. It leaves through a duct cored above the roof of the

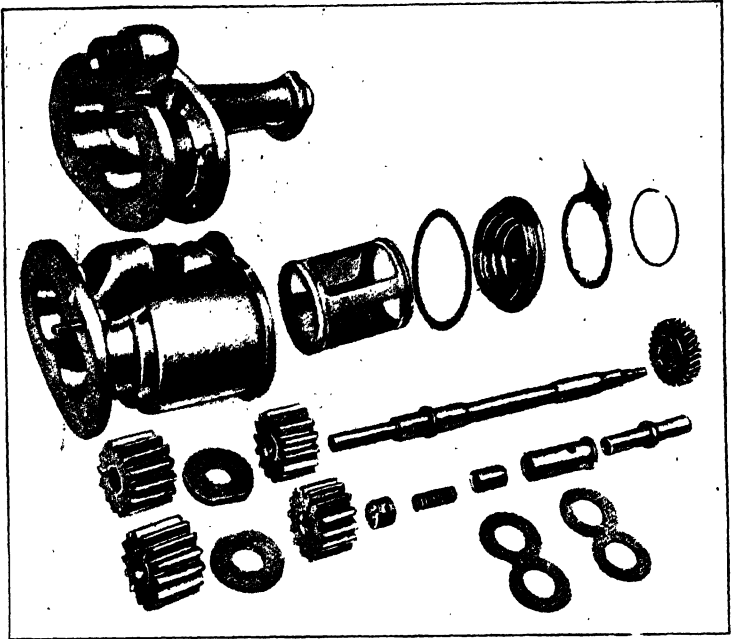


FIG. 35. Components of oil pump.

pump chamber. This duct terminates in a port in the upper face of the casting. One corner of this port can just be seen beside the driving spindle standard in fig. 34. The upper end of the hollow idler wheel spindle projects through the end of its bush into the delivery duct from the feed pump. Oil passes down the bore of the spindle and, when the pressure exceeds 85 lb. per sq. in., lifts a pressure relief valve built into its lower bush.

105. Oil enters the scavenge pump filter housing, which is cast beneath the scavenge pump casing, through the lowest of the three unions. It passes through a gauze cylinder

mounted between the roof of the chamber and a plug screwed into its lower end. The filter may be removed for cleaning by unscrewing the plug, which is secured by means of a locking washer and retaining ring. After passing through the filter the oil enters the scavenge pump itself through a hole formed in the floor of the chamber. The oil is delivered to the heater box through the centre union of the pump unit.

106. The bush in which the lower end of the driven wheel spindle is accommodated, and into which the pressure relief valve is built, projects through the floor of the scavenge pump into the interior of the filter casing. The lower end of this bush is bored to a greater diameter than that which provides the bearing surface for the lower end of the driven spindle. This end of the bush accommodates a thimble, the flat upper end of which beds on a flat seating formed by the increase in the bore of the bush. The thimble is held up to its seating by a coil spring anchored against a duralumin plug screwed into the lower end of the bush. The lower end of the bush is slotted to permit the plug to be split-pinned in any one of several positions. Four oil release holes are drilled in the bush below the seating for the thimble. The oil passed by the valve is delivered to the filter chamber through these holes.

107. In order that the end clearance of the pinions in the pump casings may be adjusted, steel shims are supplied. These are shaped somewhat like the figure 8 and are fitted between the pinions and the ends of their casings. They are supplied in thicknesses of 0.004 in., 0.007 in., and 0.010 in.

Breather

108. A sectioned perspective view of one of the breathers mentioned in paras. 35 and 37 is given in fig. 15. The two portions of the body and the non-return valve are of aluminium, the separator plate is of brass, and the baffle of steel. A long stud fitted to the mounting plug screwed into the front cover or the adaptor retains each breather in place. When the pressure in the crankcase rises above atmospheric pressure, the non-return valve is lifted and oil mist rises through the large holes in the mounting plug and passes upwards around the plates of the baffle. Much of the oil is trapped by the baffle and drains to the base of the baffle chamber. After leaving the baffle chamber the mixture of oil and air passes upwards through the separator plate and follows the path indicated by the arrows in fig. 15. In passing through the aluminium shavings carried in the upper and lower portions of the breather, nearly all the remaining oil is removed from the air before it escapes to the atmosphere. Oil trapped in the shavings also drains to the base of the breather. The

oil thus reclaimed is drawn through the small holes drilled radially in the mounting plug when the non-return valve is drawn down on to its seating on a depression occurring in the crankcase.

Airscrew hub

109. The two main components of the airscrew hub are an internally serrated flanged sleeve, known as the hub body, which is mounted on the front end of the crankshaft, and an internally splined flanged sleeve, or nave plate, mounted on the hub body. The airscrew is clamped between the flange of the hub body and the nave plate. The components are shown in fig. 36, and the hub is shown assembled on the crankshaft in fig. 37.

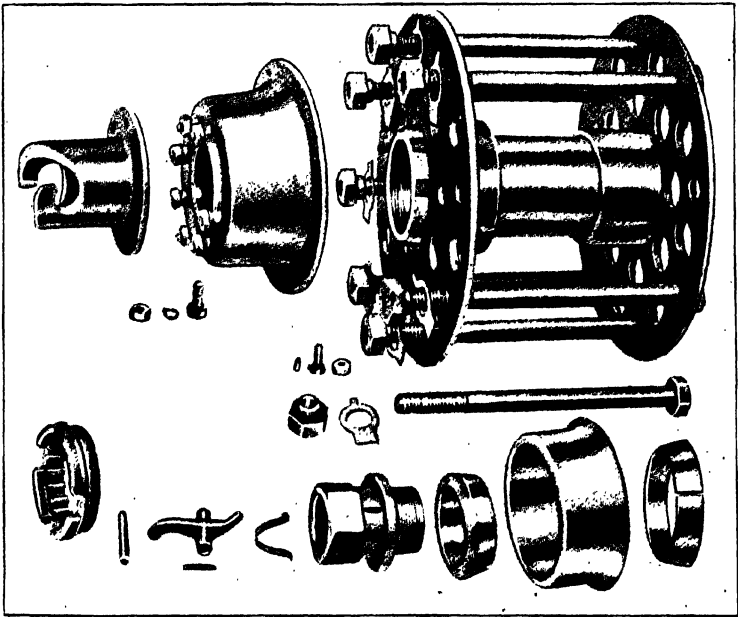


FIG. 36. Components of airscrew hub.

110. The serrations in the bore of the hub body engage the serrations in the front end of the crankshaft. The blank serration in the latter is engaged by a serration of double breadth in the bore of the hub, thus ensuring assembly in one position only. The centring of the hub on the crankshaft is effected by two cones seating one in each end of the hub body. The rear cone, which is of phosphor bronze, abuts against the

crankshaft front lock nut and is recessed to take the two dogs projecting from the front face of the lock nut. A split in the cone ensures that the latter is contracted on to the shaft when the hub nut is tightened. The front cone is of steel and is mounted on the front end of the shaft, beyond which it projects slightly. This cone is pressed into the front end of the hub body by a hollow flanged plug, known as the airscrew hub nut, screwed into the front end of the crankshaft.

111. Forward of its flange, which bears on the cone, a hexagonal head is formed on the hub nut and in it is mounted a spring-loaded trigger of the bell crank lever type. One end of the trigger projects through one of the faces of the head and engages the space between one pair of a series of splines machined around the interior of a ring nut screwed into the front end of the bore of the hub body. The other end of the trigger projects through the front end of the hub nut. The latter cannot therefore be rotated until the trigger is manipulated so that its outer end is withdrawn from between the splines around the interior of the ring nut, which is itself prevented from turning in the mouth of the hub body by a grub screw. The ring nut is of sufficient depth to arrest the flange around the hub nut when the latter is unscrewed. This action therefore withdraws the hub from the rear centring cone.

112. The nave plate is drawn up against the airscrew boss by eight bolts and nuts. The latter have cylindrical extensions for location in the holes in the nave plate and are locked by means of tab washers. The airscrew is not mounted directly upon the hub body, but upon an aluminium bush at the rear and on the cylindrical portion of the nave plate at the front.

113. A pressed steel spider upon which is mounted a claw for the engagement of a Hucks starter is bolted to the nave plate. The heads of the bolts are countersunk into the nave plate and are prevented from turning by silver steel pegs, thus enabling the spider to be dismantled without unscrewing the nuts of the airscrew bolts.

114. Some engines which have been reconditioned from the Lynx IV standard are provided with hubs fitted with an early type of nave plate and spider. Instead of the latter being attached to the nave plate by separate nuts and bolts, it is attached by the nuts of the airscrew bolts. This necessitates removal of these nuts in order to obtain access to the hub nut for removal of the hub. Some nave plates also have no cylindrical portion, in which case the front end of the airscrew is mounted upon an aluminium bush.

To face p. 62.

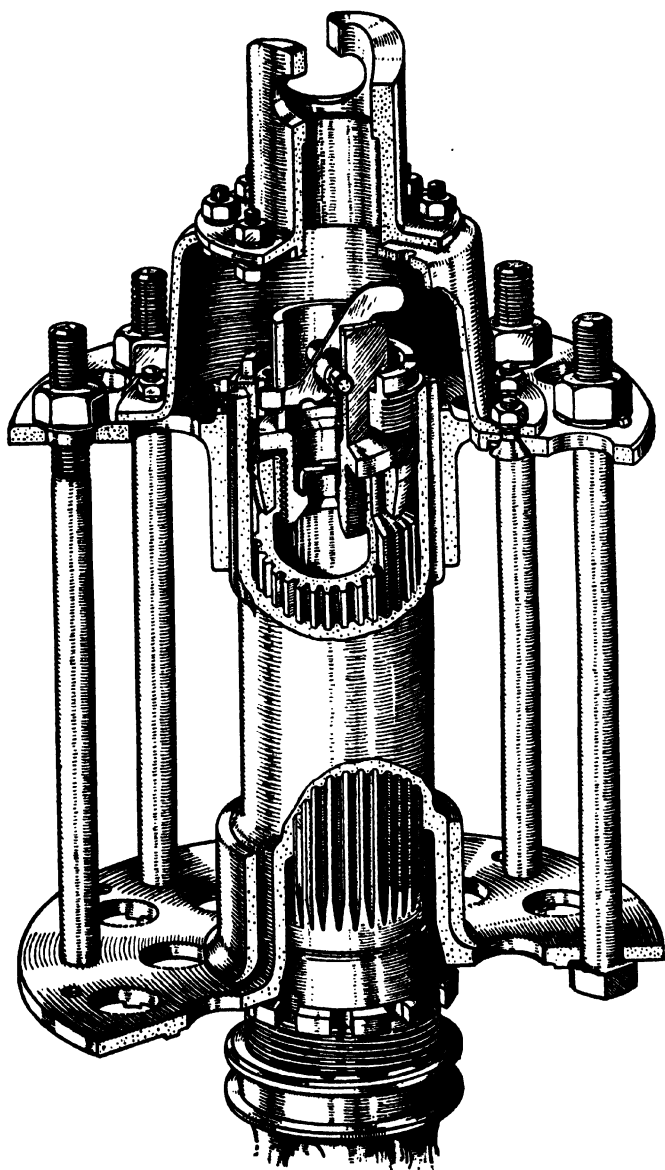


FIG. 37.

AIRSCREW HUB

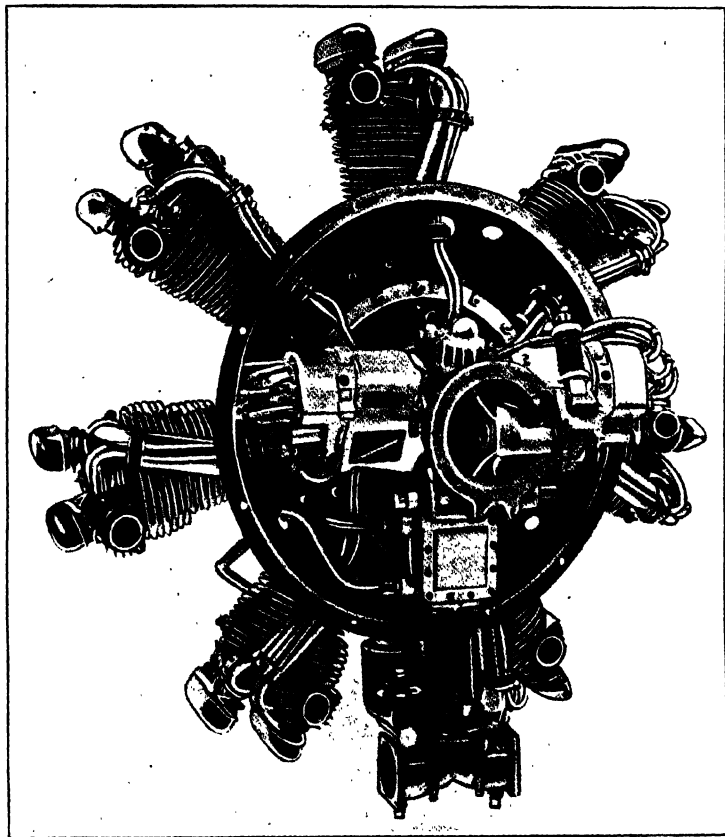


FIG. 38. Rear view of engine.

CHAPTER II**Installation and Running****Unpacking**

115. (i) Remove the bolts from the lower ends of the lifting straps attached to the sides of the packing case and lift the top and sides clear of the base. Ensure that a vertical lift is obtained, as there is only a small clearance between some of the cylinder heads and the sides of the case. The engine is bolted to a stand attached to the base by four long bolts and nuts.

(ii) Remove all loose packing material and detach the airscrew hub, carburettor and oil pipes, which are packed separately in the base of the case.

(iii) Remove the nuts by which the engine mounting plate is attached to the wooden stand, screw the lifting eye into the end of the crankshaft, attach a sling (No. 4, Stores Ref. 4A/888) to the eye and lift the engine clear of the stand.

(iv) Remove all foreign matter from the exterior of the engine and clean off all rust preventive with a brush dipped in petrol.

(v) Re-sling the engine from the lifting eyes on the crankcase. A sling must also be passed round the front of the crankshaft, as shown in A.P. 1461/G.37/sheet 17.

Installing

116. (i) Sling the engine into position against the engine bearer in the airframe.

(ii) Bolt the engine to the bearer starting at the top and working downwards. Tighten the nuts evenly and keep the weight of the engine on the crane until all the nuts are tight. Split-pin the nuts.

(iii) Clean the carburettor and remove all blanks. Remove the blanking plates from the heater box and rear cover. Ensure that the faces are clean and free from burrs. Fit the Alcumite washer to the rear cover and fit the carburettor and heater box. Fit the carburettor steady bracket and air intake.

(iv) Connect up the carburettor fuel supply union to the supply pipe in the airframe, having checked the rate of flow of the fuel. The minimum rate of flow for Lynx IV* engines is 4 pints per minute.

(v) Set the throttle lever in the cockpit and throttle lever on the carburettor to the closed positions and connect up the control rod. Check the control at the slow running and full throttle positions. In the closed position the lever in the cockpit should be off the stop. Connect up and check

the mixture control in a similar manner. The throttle lever should have a greater travel than the mixture control lever, otherwise mixture control will be inadequate at cruising speeds. The mixture control lever should clear the stop at the closed throttle position to enable the throttle to be closed positively.

- (vi) Connect up the engine speed indicator drive.
- (vii) Connect the pipes between the following parts. The oil feed pipe is connected at a later stage.
 - (a) The scavenge pump outlet union and the heater box lower union.
 - (b) The heater box upper union and the rear cover lower union.
 - (c) The rear cover upper union and the oil tank.
 - (d) Engine priming pump and priming ring.
 - (e) Drain pipe from air intake.
 - (f) Oil pressure gauge union on front cover to oil pressure gauges.
 - (g) The oil thermometer bulbs to their pockets.
- (viii) Connect up the cables from the hand starting magneto to the main magnetos.
- (ix) Connect up the main and hand-starting magneto switches and check the continuity of the circuits by means of a lamp and battery test.
- (x) Connect up the control cable to the operating lever of the hand starter gear.
- (xi) Remove the dummy sparking plugs.
- (xii) Fit the airscrew. Ensure that the latter is tight on the hub and that the hub is correctly secured and locked to the crankshaft (*see* para. 132.)
- (xiii) Clean the oil filters and allow all oil to drain from the crankcase by disconnecting temporarily the pipe connecting the engine body to the scavenge pump.
- (xiv) Turn the airscrew through at least two revolutions to expel any surplus oil that may have drained into the lower cylinders and induction pipes.
- (xv) Prime the oil feed pump and the oil supply pipe. Connect the latter to the pump.
- (xvi) Remove one of the blanking plugs from the top of the engine body and pour in three quarts of hot engine lubricating oil. Replace the blanking plug and washer and lock the plug with wire.
- (xvii) Inject hot engine oil into the filler cup on top of the engine speed indicator drive unit until it overflows from the levelling cock on the port side of the rear cover. Turn

off the cock. The handles of all level cocks are in a vertical position when closed. During this operation the engine should be in flying position.

(xviii) Grease all push-rod ends and rocker bearings.

(xix) Lubricate the magnetos in accordance with A.P. 1374/C2, C.8.

(xx) Remove the filling plug on top of the wormshaft casing and pour in hot engine oil until it overflows from the levelling cock in the base of the casing. Turn off the cock.

(xxi) Clean and if necessary adjust all sparking plugs, smearing the threads with graphite grease and fitting new washers before screwing them into their adaptors.

(xxii) Examine all external nuts, ensuring that they are tight and locked correctly.

(xxiii) With all the magnetos switched off, turn the engine by means of a Hucks starter until the oil pressure gauge registers a pressure. Turn off the cock in the oil supply pipe. If a Hucks starter is not available the engine must be turned by hand.

(xxiv) Fit the cowling and other aeroplane parts.

Starting

117. The following instructions apply to starting the engine with the hand starter gear or with a Hucks starter.

- (i) If the engine has been standing for any length of time, remove the sparking plugs and turn the engine through at least two revolutions to expel any oil that may have drained into the lower cylinders and induction pipes (*see* para. 120). Examine and if necessary clean and adjust the sparking plugs and replace them, previously smearing the threads with graphite grease and fitting new washers.
- (ii) Turn on the fuel and oil cocks, ensuring that they are held positively in the open position.
- (iii) See that all magnetos are switched off.
- (iv) Open the throttle slightly.
- (v) Turn and prime the engine. The minimum amount of fuel consistent with satisfactory starting should be injected into the inlet ports, as the fuel tends to wash the lubricating oil from the cylinder walls. Under normal weather conditions with a cold engine six strokes of the priming pump should be given. If cold weather conditions prevail, two additional strokes of the priming pump should be given as the engine starts. If the engine is warm give two strokes of the priming pump, at the same

time turning the engine through two revolutions. Never jerk a warm engine over compression in case it fires, even with the ignition switched off. If a Hucks starter is being used, an oil pressure should be registered on the gauge ; failure to register a pressure should be investigated at this stage.

- (vi) If an engine not equipped with a hand starter gear is being started, stand clear of the airscrew and turn the hand-starting magneto. As soon as the engine fires, switch on the main magnetos and switch off the hand-starting magneto. Should the engine fail to fire, switch off the hand-starting magneto and turn the engine until the piston of the next cylinder is on the firing stroke and repeat the procedure. When starting by means of a hand starter gear or Hucks starter, turn the engine, switch on the hand-starting magneto and turn the latter until the engine fires. Switch on the main magnetos and switch off the hand-starting magneto.
- (vii) Having started the engine, run it at 600 r.p.m. for about one minute.

Warming up

118. (i) When running the engine at 600 r.p.m., note the oil pressure. At first a high pressure will build up due to the viscosity of the cold oil ; should this pressure tend to exceed 100 lb. per sq. in. the engine must be run at a lower speed. As the engine warms up the pressure will gradually decrease to a pressure which must not be less than 60 lb. per sq. in. Should the pressure fall below 60 lb. per sq. in. when the engine is thoroughly warm, the engine must be stopped and the cause investigated. The trouble will probably be due to an air leak in the feed pump supply pipe.

(ii) As soon as the oil pressure gauge shows a steady reading, run the engine at the speed which suits it best between the limits of 800 and 1,000 r.p.m. Continue running at this speed until the oil circulation is well established and a rise of 10° C. is obtained above the initial cold starting temperature. Do not run at this speed for more than five minutes.

(iii) Accelerate steadily up to 1,600 r.p.m., and check the ignition systems and mixture control. To check the ignition systems, switch off each magneto alternately and read the reduction in r.p.m. ; should the reduction exceed 50 r.p.m., examine the system for faulty sparking plugs, magnetos or ignition cables. An inch of travel of the mixture control lever towards the weak position should cause a reduction in

r.p.m. Accelerate steadily up to full throttle, avoiding instrument surge. The engine should not be run on the ground at full throttle for periods greater than one minute, as normal cooling does not obtain until the aeroplane is in flight.

(iv) When the engine is warm, it should run at a speed not exceeding 400 r.p.m. with the throttle in the slow running position.

Stopping

119. After flight the engine should be stopped by turning off the fuel and allowing the engine to run slowly until irregular firing commences, when the ignition should be switched off and the throttle opened fully at the same time. This period of slow running allows the cylinders and working parts to cool gradually, so that the oil will not so readily drain from them after the engine has stopped, and hence the danger of "drying-up" when the engine is next started will be minimised. If the oil tank is above the oil pump, the oil cock must be closed after stopping the engine to prevent oil draining through the pump into the crankcase.

120. If the engine is not to be run for several days, the airscrew should be turned so that the inlet valves of the lower cylinders are closed. If the engine is left with these valves open, there is a possibility of oil draining past the valves into the U-shaped chambers formed by the induction pipes and inlet ports. On starting up the engine subsequently the velocity of the mixture is not sufficient to scavenge this oil at slow engine speeds, but on opening the throttle the velocity of the mixture increases, and the latter carries with it into the combustion chambers a comparatively large volume of oil. The resulting high compression is sufficient to over-stress and even damage the connecting rods concerned.

PART II—MAINTENANCE AND WORKSHOP PRACTICE

CHAPTER III

MAINTAINING THE ENGINE

General

121. In this chapter the methods of effecting certain maintenance operations and adjustments are given. The times at which these and other operations should be effected will be found in Vol. II, Part 2, of the handbook on the aeroplane in which the engine is installed.

122. Of the subsequent chapters the first describes the dismantling of the engine into unit assemblies with the appropriate tools. Successive chapters describe details of stripping, examination, replacement of components and erection of the various assemblies. The erection of the complete engine is dealt with in Chapter XIII.

Tool kits

123. Two tool kits are issued for use with the engine. One kit, the flight tool kit, contains all tools that are required for normal maintenance work on the engine. The second kit, the workshop kit, contains all tools included in the flight tool kit together with most of the tools necessary for a complete strip and assembly of the engine and its components. The workshop tool kit is divided, for the sake of convenience, into two separately boxed kits known as workshop tool kit No. 1 and workshop tool kit No. 2. In addition to the flight and workshop tool kits, certain additional tools are provided. These tools are necessary for the completion of the dismantling of certain engine components and for the fitting of new parts. A number of rigs for checking clearances and backlash are also listed with these additional tools, which are known as jigs and special tools. All tools for use on the Lynx IV aero-engine are listed in Vol. III of this air publication whilst certain additional or different tools for use with the Lynx IV (Mod.) and IV* aero-engines are listed in Addenda 1 and 2 respectively to Vol. III.

124. Only the tools normally required for maintaining the engine are listed and described in this chapter. Those required for dismantling the engine into assemblies are dealt with in the next chapter, whilst the remaining tools are used during overhaul of the unit assemblies or erection of the engine and are therefore described in their appropriate chapters. Further general information on tool kits is given in A.P. 1464, Vol. 1, Part 4, Sect. 1, Chap. 1, paras. 4 and 5. Where it is necessary in the text to refer to a tool built up of a number of parts, the maker's part number stamped on

its largest component is quoted. In the lists of tools the letters given in the column headed "Classification" are to be interpreted as follows:—

"F" indicates that the tool is supplied in both flight and workshop tool kits.

"W.1", or "W.2" indicates that the tool is supplied in workshop tool kit No. 1 or No. 2.

"J" indicates that the tool is issued separately under the heading of jigs and special tools.

Items marked with an asterisk are obsolescent.

125. Tools normally required for maintenance of the engine.

Stores Ref. Section 36U.	Part No.	Description.	Classifi- cation.
904	S.R.5734	Piston position indicator	F
4905	Enots 3177	Grease gun for valve gear	F
4908	S.R.5590	* $\frac{9}{16}$ in. Whit. box spanner for spark- ing plugs.	F
4908	S.R.25339	$\frac{9}{16}$ in. Whit. box spanner for spark- ing plugs.	F
2041	S.R.27962	$\frac{1}{2}$ in. Whit. box spanner for spark- ing plugs.	F
4909	S.R.2589	Box spanner for cylinder locking rings.	F
4910	S.R.5591	Box spanner for oil pump bottom cover.	F
4914	S.R.5593	Spanner for nuts securing induction pipes.	F
4918	S.R.5592	Ring spanner for airscrew hub nut.	F
4972	S.R.2158	Tool for cylinder head locking ring.	F
4919	S.R.5596	* Valve spring depressing tool ..	F
2052	S.R.28763	Valve spring depressing tool ..	F
4922	E.N.3003	Valve holding tool. (Shown in fig. 39.)	F
6556	S.R.16927	Valve clearance gauge (hot and cold)	F
6561	S.R.22535	Lever for removing push rods ..	F
6564	S.R.11715	Spanner for push rod socket in rocker.	F
6576	S.R.11716	Spanner for rocker clamping bolt ..	F
4997	S.R.9426	Spanner for nut securing claw to magneto drive shaft.	F
4974	S.R.32412	Setting gauge for hand turning gear	W.1
37C/2131	S.R.3043	Jet key for carburettor	F
37C/2132	S.R.5758	Box spanner for plugs of carburettor jet wells.	F
37C/2133	—	Spanner for float chamber cover ..	F
37A/3772	—	Box spanner for magneto cam screw	F
37A/3776	—	Spanner with screwdriver and gauge for magneto.	F
37A/3778	—	Spanner for nuts clamping cables ..	F

Checking and adjusting valve tappet clearances

126. The tappet clearances of each cylinder must be checked with the gauge S.R.16927. Care must be taken to use the correct feeler, depending upon whether the engine is hot or cold, and, if cold, whether the inlet or exhaust valve tappet clearance is being checked. The piston of the cylinder being worked upon must be at T.D.C. on the power stroke, when both valves will be closed. To adjust the clearance, slacken the rocker clamping bolt by means of the spanner S.R.11716 and screw the threaded socket into or out of the rocker by means of the spanner S.R. 11715. When the correct clearance is obtained between the rocker striking pin and the end of the valve stem, tighten the clamping bolt. When the tappet clearances of any cylinder have been checked, the clearances of the next cylinder but one to it in a clockwise direction may be adjusted if the airscrew is turned through an angle of about 100° in the same direction.

Lubrication of the rocker sockets

127. To lubricate the joints between the rocker sockets and the outer ends of the push rods, the sockets should be unscrewed out of the rockers in the manner described in the preceding paragraph, and a small quantity of valve gear grease, Stores Ref. 34A/54, injected into them. The condition of the push rod ends and of the thrust pads should be observed at the same time. After replacing the sockets the valve clearances must, of course, be adjusted.

Changing valve springs with the cylinders in position

128. (i) Turn the crankshaft until the piston of the cylinder to be worked on is approximately at T.D.C. on the power stroke. Remove the rockers and tie the two shims fitted on each side of them to the rockers concerned to prevent loss or confusion.

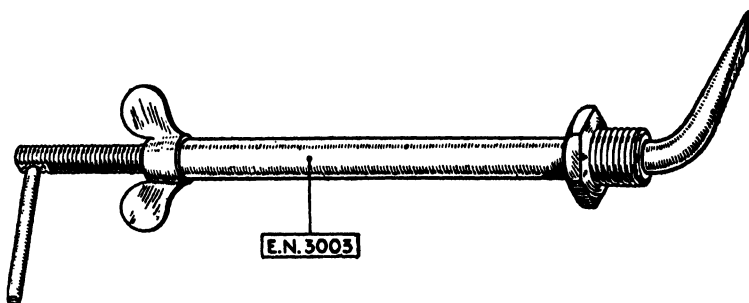


FIG. 39. Valve holding tool.

(ii) Remove the sparking plug adjacent to the valve to be worked on, and, after slackening the wing nut of the valve holding tool E.N. 3003 (*see* fig. 39), insert the hooked end of the tool through the sparking plug adaptor and screw the body plug home. Turn the hooked end of the tool by means of the tommy bar so that it engages the head of the valve, and tighten the wing nut.

(iii) Using either of the valve spring depressing tools S.R.5596 (double-handled) or S.R.28763 (single-handled), compress the valve springs sufficiently to allow the halves of the split cotter sleeve to be removed. Release the valve springs and remove them.

(iv) After substituting the new springs, assemble the components in the reverse order to dismantling. Finally, adjust the valve tappet clearances if necessary and charge the rocker bearings with grease.

Testing the cylinder barrel locking rings for security

129. The cylinder barrel locking rings should be tested for security when the engine is hot. The rings frequently bind between the engine body and cylinder and consequently give a false impression of tightness. To ensure that the rings are really tight they should be tapped all round with a copper or aluminium drift whilst the clamping screw is tested. A special spanner S.R.2589, designed so that hard hand pressure will produce the desired degree of tension, is supplied for tightening the clamping screws. On no account must a length of tubing be employed to increase the leverage of this spanner, otherwise the clamping screw will be bent and the cylinder distorted. If the width of the gap between the bosses of any locking ring is not between the limits of $\frac{3}{8}$ in. and $\frac{1}{2}$ in., the cylinder must be removed and the adaptor adjusted as described in para. 257.

Testing the cylinder head locking rings for security

130. The cylinder head locking rings should be tested for tightness when the engine is hot by means of the drift tool S.R.2158. If a ring is found to be loose, which is of rare occurrence, the cylinder head will in all probability also be loose. The ring must therefore be loosened further and the head tightened on the barrel by a hide hammer or wooden bar inserted in a valve port after the induction and exhaust pipes have been removed. The locking ring must not be re-tightened until the engine is cold, and must be further tightened when the engine is warmed up. It may be necessary, after the head has been tightened, to loosen the barrel locking ring and turn the cylinder slightly in its socket so as to align the valve ports with the induction and exhaust

pipes. The barrel locking ring must then be re-tightened as described in the preceding paragraph. If it is found necessary to tighten the head it will also be necessary to adjust the valve tappet clearances.

Removing the airscrew and hub

131. To remove the airscrew and hub, the spider on which is mounted the claw for the engagement of a Hucks starter must first of all be removed from the front flange of the airscrew hub. On early hubs, this will necessitate undoing the tab washers and nuts of the airscrew bolts, but on later engines this is unnecessary, as the spider is attached to the front flange by separate bolts and nuts. Removal of the spider will enable the double-handled spanner S.R.5592 to be applied to the hollow flanged plug screwed into the front end of the crankshaft. This spanner automatically disengages the locking trigger, and therefore no other type of spanner must be used. The mechanism of the locking device is described in para. 111. On unscrewing the plug, the flange of the plug engages the ring nut screwed into the front of the sleeve portion of the flanged sleeve, and therefore withdraws the hub.

Fitting the airscrew and hub

132. Coat the rear centring cone and the crankshaft splines with engine oil and slide the cone into position, ensuring that the recesses in the rear face of the cone engage the dogs on the crankshaft front lock nut. Failure to lubricate the cone thoroughly may result in difficulty due to sticking during subsequent dismantling. The airscrew and front flange having been bolted to the flanged sleeve, the hub may now be fitted to the crankshaft. Ensure that the wide serration in the bore of the flanged sleeve lines up with the wide serration on the crankshaft. When screwing up the hollow flanged plug by hand the locking device must be disengaged, but the latter is automatically disengaged when using the spanner S.R.5592. After hammering the handle of the spanner to tighten the plug fully, the trigger of the locking device must be free with the outer end bearing on the face of the plug. If this is not so, the inner end of the trigger is not engaging one of the slots in the bore of the ring nut and the plug is not locked. The plug must never be slackened to enable the trigger to be engaged. The spider for the Hucks starter claw can now be attached to the front flange and the nuts of the airscrew bolts locked by means of the tab washers.

Removing and replacing tappet guides with the engine in the airframe

133. Tappet guides may be withdrawn from the engine body as follows after the push rods which they operate have been removed as instructed in para. 139. Only those engines

having the tappet guides and sockets marked as described in paras. 206 to 208 may have the guides removed by this method.

- (i) Remove the split-pin and nut from one of the retaining bolts. With a small screw-driver, expand the ends of the circlip around the bolt and work the circlip clear of its groove. As soon as the circlip is clear of the groove, engage the end (Y) of the tool (K) of fig. 40 with the circlip groove ; the tool will then grip the bolt and prevent it from falling into the engine body whilst the circlip is being removed. Having removed the circlip, screw one of the sleeves (J) over the end of the bolt until the upper of the two holes through the sleeve registers with the split pin hole through the bolt. Pass one of the pins (I) through both sleeve and bolt and then remove the tool (K). Next carry out the same operation on the second bolt.
- (ii) Having fitted the sleeves (J) to the tappet guide retaining bolts, the extraction of the guide is completed as follows. Withdraw the retaining bolts by pulling the sleeves (J) as far as possible through the tappet guide and turning them until it is felt that the heads of the bolts are actually engaged in the recesses in the engine body ; this will be evidenced by the fact that the bolts will then be locked against turning. Then, without releasing the sleeves, lower them once more until their lower ends are resting on the tappet guides and give each sleeve a half turn ; this will turn the projecting heads of the bolts clear of the tappet guide socket in the engine body. The looped ends of the pin (I) will then be located nearer the cylinder.
- (iii) Secure the bridge piece (G) fitted with the extractor screw (B) to the ends of the sleeves (J), turning each sleeve through the smallest angle necessary to enable the flats at its outer end to engage the slots in the bridge piece. The bridge piece is to be secured to the sleeves by the setscrews (E) and washers (F).
- (iv) Lower the extractor stirrup (D) over the extractor screw and bridge piece and turn it so that it seats correctly upon the engine body. Screw home the nut (A) ; this will withdraw the guide from its socket. Any tendency of the extractor screw to turn may be checked by a tommy bar through its outer end.

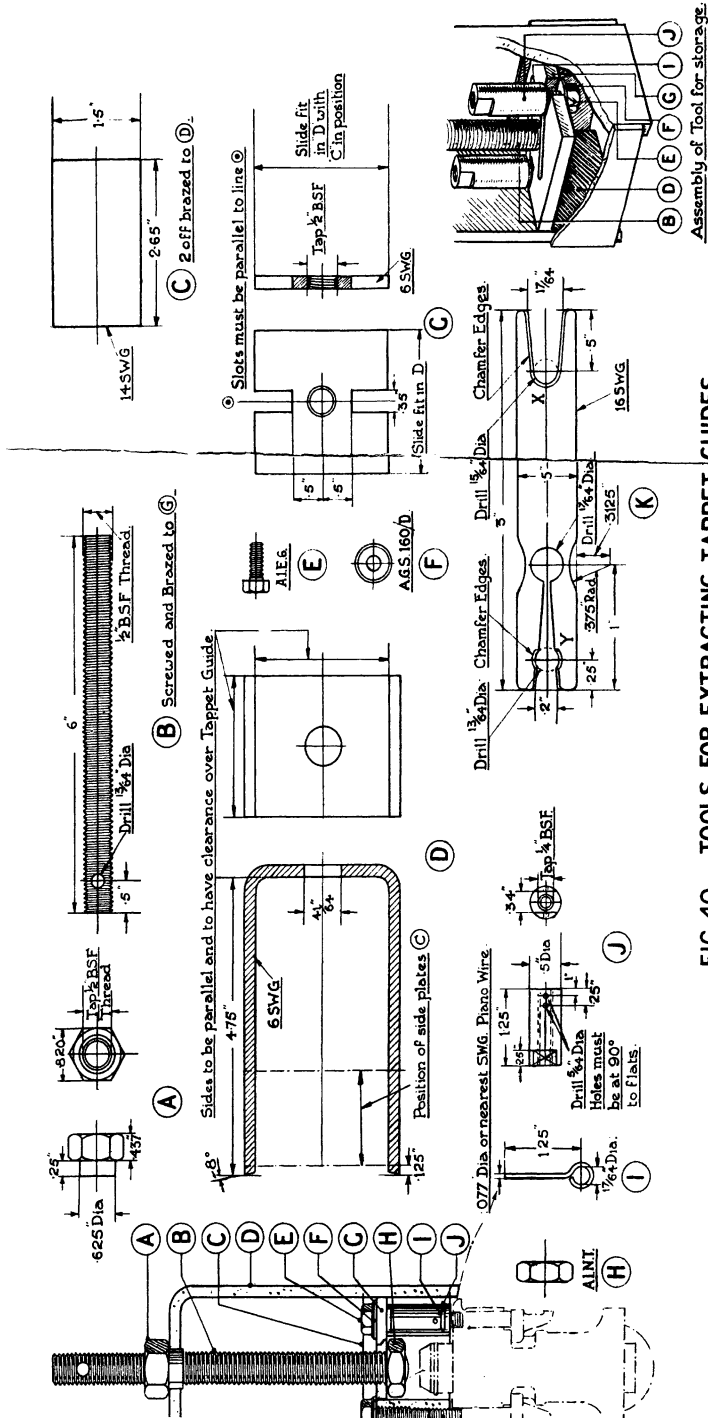


FIG. 40. TOOLS FOR EXTRACTING TAPPET GUIDES.

Assembly of Tool for storage.

134. A new tappet guide, fitted with tappets and retaining bolts, may be driven into its socket after its shank has been talloved and the heads of the bolts turned so as to clear the sides of the socket. Nuts should be fitted to the retaining bolts to prevent the latter falling into the engine body, but they should not be drawn up tight. Care should be taken to position the guide before driving it home so that the line through the centre line of the tappets is as nearly at right-angles to the face of the engine body as possible, since the guide will have to be drifted round into this position when finally home. After the guide has been driven home, it must be turned in its socket until the marks on the flange and engine body are in line. The guide should be turned in its socket by a wooden drift applied to one of the tappets. Having aligned the tappets, the circlips must be fitted to the tappet guide bolts. The circlips may be fitted most easily by withdrawing each bolt in turn through the guide till its head engages the recess in the engine body, and retaining it in this position with the end (Y) of tool (K) of fig. 40 whilst the circlip is worked over the threaded portion of the bolt. When the circlip has been worked down close to the tool, the tool and nut should be removed. The hole in the end (Y) of the tool should then be passed over the end of the bolt, the nut replaced and tightened until it is felt that the circlip has entered its groove; the nut and tool may then be removed. The fitting of the enclosed type push rods may next be proceeded with as described in paras. 269 and 270.

Adjustment of the hand starter gear

135. Adjustment of the hand starter gear is of primary importance, as maladjustment of this component will cause rapid wear of the claws. The gear must be checked at the intervals laid down in A.P. 1287/H.1, for the following :—

- (i) Correct angle of the spring-loaded sliding head with the gear engaged.
- (ii) Correct clearance between the claws with the gear disengaged.
- (iii) Correct loading of the spring with the gear engaged.
- (iv) Correct length of the spring with the sliding head in the dead centre position.

136. The sequence of operations for checking these four items is as follows :—

- (i) With the hand starter gear attached to the rear cover and the claws engaged, turn the starting crank handle slowly to ensure that the starter claw is fully engaged with the engine claw.

- (ii) Attach the setting gauge S.R.32412 to the starter end cover, as shown in A.P. 1287/H.I. Ensure that the spring washers fitted beneath the two nuts are removed from the studs, thereby allowing the gauge to seat correctly on the outside of the end cover. Measure by means of feeler gauges the difference in the clearances between the gauge face and the upper and lower spring anchorage cups.
- (iii) Remove the gauge from the end cover and disengage the claws. Remove the starter from the rear cover, taking care not to disturb the magneto timing, as there is a possibility of the housing of the magneto drive shaft bearing, which is clamped between the rear cover and starter casing, being withdrawn slightly from the rear cover; this draws the magneto driving bevel out of engagement with the driven bevels. Whenever the starter is removed, therefore, the following procedure should be adopted :—
 - (a) Slacken the six nuts securing the starter to the rear cover until the spring washers are just free, and tap the starter casing from the rear in order to break the joint between the starter and bearing housing.
 - (b) Holding the bearing housing against the rear cover, remove the nuts, spring washers and starter, still maintaining a pressure on the flange of the bearing housing.
 - (c) Secure the bearing housing in position by two nuts and washers until the starter is to be replaced.
- (iv) If the sliding head is not parallel to the gauge face within the tolerance laid down in A.P. 1287/H.I., unlock the tab washer of the nut retaining the claw to the magneto drive shaft and remove the nut and claw. If the clearance between the upper spring anchorage cup and the gauge face exceeds that between the lower spring anchorage cup and the gauge face, a shim or shims must be added between the inner race of the magneto drive shaft and the claw. Conversely, if the clearance between the lower spring anchorage cup and the gauge face exceeds that between the upper spring anchorage cup and the gauge face, a shim or shims must be removed. Shims are obtainable in thicknesses of 0.004 in. and 0.009 in.

- (v) Replace the claw, tab-washer and nut on the magneto drive shaft, fit the starter and check the angle as instructed in sub-paras. (i) and (ii). Repeat until the angle is within the tolerance. Finally, remove the starter, fit a new tab-washer to the nut retaining the engine claw and tighten and lock the nut.
- (vi) Next check the clearance between the claws with the starter disengaged. Using a depth gauge, measure the distance from the face of the attachment flange on the hand starter casing to the tips of the starter claw. Also measure, by means of a height gauge, the distance between the face for the starter on the rear cover and the tips of the engine claw. The difference between the two measurements give the clearance. If the latter is less than the permissible minimum, disengage the claws and file the stop in the casing against which the sliding head bears when in the disengaged position until the required clearance is obtained.
- (vii) Refit the starter to the rear cover and set the loading on the spring with the claws engaged. Remove the split pin securing the upper spring anchorage cup nut and slacken the nut until the split pin can just be fitted. Engage the claws and turn the engine slowly by means of the starting handle. If, when turning the engine over compression, the sliding head is seen to move, indicating that the starter claw is riding up the engine claw due to insufficient spring loading, tighten the nut half a turn. Turn the engine again and proceed alternately to tighten the nut and turn the engine until no slip of the claws occurs. The spring must not be loaded more than is absolutely necessary to obtain this condition. Finally, lock the nut with a split pin.
- (viii) Check the length of the spring with the sliding head in the dead centre position by means of the slip gauge on the side of the setting gauge S.R. 32412. It must be possible to insert the slip gauge between the upper and lower spring anchorage cups. A new spring must be fitted if the gauge cannot be entered.

CHAPTER IV

DISMANTLING THE ENGINE

General (including tools)

137. Before commencing to dismantle the engine into unit assemblies it is most important that personnel should familiarise themselves with A. P. 1464, Vol. 1, Part 4, Sects. 1, 2 and 3. These sections of the Engineering Manual describe the workshop equipment, other than tools, that is required for overhaul, also the general precautions to be taken during dismantling and the methods of cleaning components. A list of the tools required is given below.

Stores Ref. Section 36U.	Part No.	Description.	Classification.	Illustrated in Fig.
6561	S.R.22535	Lever for removing push rods.	F	—
4914	S.R.5593	Spanner for nuts securing induction pipes.	F	—
4909	S.R.2589	Box spanner for cylinder locking rings.	F	—
4967	S.R.5621	*Tube spanner for ring nuts on crankshaft.	W·1	—
4967	S.R.11569	Tube spanner for ring nuts on crankshaft.	W·1	—
		EXTRACTOR FOR FRONT COVER, <i>consisting of</i> :—		
4945	S.R.2134	Draw bolts and nuts (2 off).	W·1	41
4949	S.R.2136	Yoke plate (1 off) ..		
4952	S.R.2135	Draw plate (1 off) ..		
4958	S.R.2122	Plug for front end of crankshaft (1 off).		
4964	S.R.2123	Extractor screw (1 off) ..		
		EXTRACTOR FOR EARLY TYPE THRUST BEARING CARRIER, <i>consisting of</i> :—		
4946	S.R.2127	Draw bolts with nuts (4 off).	W·1	42
4949	S.R.2136	Yoke plate (1 off) ..		
4953	S.R.2170	Draw plate in halves (1 off)		
4958	S.R.2122	Plug for front end of crankshaft (1 off).		
4964	S.R.2123	Extractor screw (1 off) ..		
4961	S.R.5022	Locking ring plate (1 off)		

Stores Ref. Section 36U.	Part No.	Description.	Classi- fica- tion.	Illus- trated in Fig.
		EXTRACTOR FOR DRIVING SLEEVE, <i>consisting of</i> :—		
4944	S.R.2132	Draw bolts and nuts with plates (2 off).	W·1	43
4949	S.R.2136	Yoke plate (1 off) ..		
4958	S.R.2132	Plug for front end of crankshaft (1 off).		
4961	S.R.5622	Locking ring plate (1 off)		
4964	S.R.2123	Extractor screw (1 off) ..		
		EXTRACTOR FOR CAM DRUM, <i>consisting of</i> :—		
4944	S.R.2132	Draw bolts and nuts with plates (2 off).	W·1	44
4949	S.R.2136	Yoke plate (1 off) ..		
4958	S.R.2122	Plug for front end of crankshaft (1 off).		
4964	S.R.2123	Extractor screw (1 off) ..		
4981	S.R.10016	Adaptor (1 off)	W 2	—
4968	S.R.2164	Tube spanner for nut securing fan.	W 1	
		EXTRACTOR FOR FAN, <i>consisting of</i> :—		
4943	S.R.2174	Bolt (2 off)	W·1	45
4961	S.R.2162	Yoke plate (1 off) ..		
4959	S.R.2126	Plug for rear end of crank- shaft (1 off).		
4964	S.R.2123	Extractor screw (1 off) ..		
2176	S.R.24816	Extractor bolt for fan induction casing.	W·1	—
4965	S.R.2177	Box spanner for nuts of master rod bolts.	W·1	—

Removing the engine from the aeroplane

138. (i) Remove the airscrew and hub (*see* para. 131).
- (ii) Remove the exhaust pipes or exhaust collector ring.
- (iii) Disconnect the cables between the magnetos and the earthing switches and hand starting magneto.
- (iv) Disconnect all oil and fuel pipes between the engine and the airframe.
- (v) Disconnect the cockpit throttle and mixture control from the carburettor.
- (vi) Disconnect the engine speed indicator drive.
- (vii) Disconnect the control from the operating lever of the hand starter gear.
- (viii) Disconnect the priming pipe from the priming ring.

- (ix) Remove the carburettor and heater box as a unit.
- (x) Sling the engine as instructed in A. P. 1464/G.37/sheet 17, and take the weight of the engine.
- (xi) Remove the engine mounting bolts and swing the engine clear, taking care not to damage the magnetos.
- (xii) Mount the engine on an engine erecting stand (Stores Ref. 4D/5), bolting the engine to the permanent plate.

Dismantling the engine

- 139. (i) Remove all sparking plugs.
- (ii) Remove the rocker covers, push rods and push rod covers. In order to remove the latter, turn the crankshaft until both valves of the cylinder to be worked on are closed. Remove the tappet sleeves and clamp screws from the rockers and the nuts which retain the push rod cover tube brackets to the tappet guides. Slide the brackets up over the cover tubes as far as possible so that they clear the retaining bolts. Next lever the push rods clear of the tappets in turn with the forked lever S.R.22535 and remove the push rods, covers and bracket as a unit.
- (iii) Disconnect the bonding wires and undo all the clips securing the ignition cables and priming pipes to the induction pipes. Release the clamps securing the ignition cables to the cylinder heads and the clips binding the cables together. Withdraw the cables through the apertures in the engine bearer.
- (iv) Unscrew the nuts that retain the magnetos to the rear cover. Mark the distributor of the port magneto to distinguish it from the starboard magneto. Remove the two magnetos complete with their ignition cables. Replace the nuts and spring washers on the retaining studs to prevent loss of the shims.
- (v) Remove the six priming pipes which radiate from the priming ring to the cylinder heads.
- (vi) Remove the locking plates securing the gland nuts at the inner ends of the induction pipes and unscrew the nuts by means of the spanner S.R.5593. Spring the tanged wire rings locking the union nuts at the outer ends of the induction pipes and unscrew the nuts, using the same spanner. Ease the induction pipes carefully out of their sockets in the induction casing.
- (vii) Turn the engine in the stand so that the front cover is uppermost.
- (viii) Remove the oil pump by removing the retaining nuts and setscrews.

Removing the cylinders and pistons

140. When removing the cylinders and pistons it is essential that No. 1, the master rod cylinder, is removed last, otherwise the master rod is free to swing about the crankpin within the confines of the cylinder adaptor. This affects the rake of the articulated rods, causing some of them to foul and distort the mouths of the cylinder barrels; it also increases the stroke of the pistons inwards so that the piston skirts are brought into the path of the balance weights, which will then damage the pistons by fouling them. If, therefore, it is necessary at any time to remove No. 1 cylinder only, great care must be taken to ensure that the small end of the master rod remains coincident with the axis of the cylinder barrel; rotation of the crankshaft should be avoided. The sequence of operations for removing all cylinders and pistons is as follows :—

- (i) Turn the crankshaft so that the piston of the cylinder to be removed is approximately on T.D.C. This prevents the piston rings from fouling the cylinder adaptor after the cylinder has been removed.
- (ii) Slacken the cylinder barrel locking ring bolt with the spanner S.R.2589 and tap the ring on the chamfer on each side of the slot with a brass or aluminium drift so as to free it.
- (iii) Inject about $\frac{1}{4}$ pint of engine oil into the cylinder to be removed and unscrew the cylinder, at the same time keeping the piston in motion by turning the crankshaft to and fro through an angle of about 45° on each side of T.D.C. This movement of the piston prevents circumferential scoring of the cylinder barrel by the piston rings.
- (iv) When the cylinder is fully unscrewed, ensure that the piston is approximately on T.D.C. and remove the cylinder. Remove one of the circlips which locate the gudgeon pin and slide the latter out by hand, at the same time supporting the piston and connecting rod. If difficulty is experienced in removing the gudgeon pin it will probably be found to be due to burring of the circlip groove. The burrs may be removed by means of a scraper. Remove the piston and replace the gudgeon pin in the piston. Circlips must be used once only, and as a precautionary measure must be fractured deliberately on removal.

Removing the front cover

141. Before withdrawing the front cover, the rear centring cone for the airscrew hub must be removed. This may be

most easily effected by inserting a wedge in the slot in the cone, thus slightly expanding the latter. Insert a soft metal pad between the rear crankweb and the rear main bearing housing in the fan induction casing. This prevents damage to the crankweb and housing after removal of the thrust bearing, which locates the crankshaft axially in the engine body. Next unscrew the crankshaft front lock nut, using the tube spanner S.R.11569; an obsolescent type of spanner is numbered S.R.5621. Unscrew the nuts that retain the plate to the mouth of the thrust housing and the front cover to the engine body. Remove the eyebolt from the front end of the crankshaft and the plate from the mouth of the thrust housing.

142. The front cover may now be withdrawn by means of the extractor shown in fig. 41. The tool should be built up and used as follows:—

- (i) Fit the draw bolts S.R.2134 to the draw plate S.R.2135 so that the heads of the bolts lie in the recesses in the plate. Fit and secure the plate to the mouth of the thrust housing.
- (ii) Place the plug S.R.2122 in the end of the crankshaft and screw the extractor bolt S.R.2123 into the yoke plate S.R.2136 so that its end is flush with the under-face of the plate.
- (iii) Lower the yoke plate over the ends of the two extractor bolts and secure it square with the end of the crankshaft by nuts screwed on to the bolts.
- (iv) Screw home the extractor bolt and so withdraw the front cover from the engine body. The latest type of thrust bearing carrier will be withdrawn with the front cover.
- (v) Remove the front cover and dismantle the extractor.

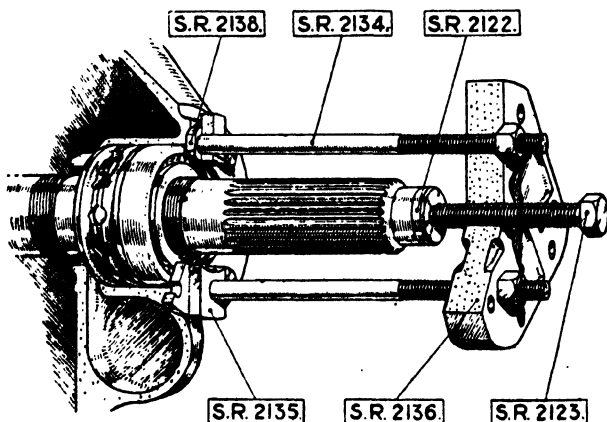


FIG. 41. Extractor for front cover.

Withdrawing the early type thrust bearing carrier

143. As this thrust bearing carrier is not provided with a flange, it remains in position on the crankshaft when the front cover is removed. It should be withdrawn from the crankshaft as follows by means of the extractor shown in fig. 42 :—

- (i) Mount each portion of the halved draw plate S.R. 2170 upon two of the four draw bolts S.R.2167 so that the recessed portion of the plate lies furthest from the heads of the bolts.
- (ii) Engage the recessed faces of the halves of the draw plate behind the rear end of the thrust bearing carrier. Locate the halves of the draw plate in this position by passing the ring plate S.R.5622 over the ends of the draw bolts and allow it to rest on the front end of the carrier.
- (iii) Repeat operations (iii) and (iv) of para. 142, and by screwing home the extractor bolt, withdraw the thrust bearing carrier.

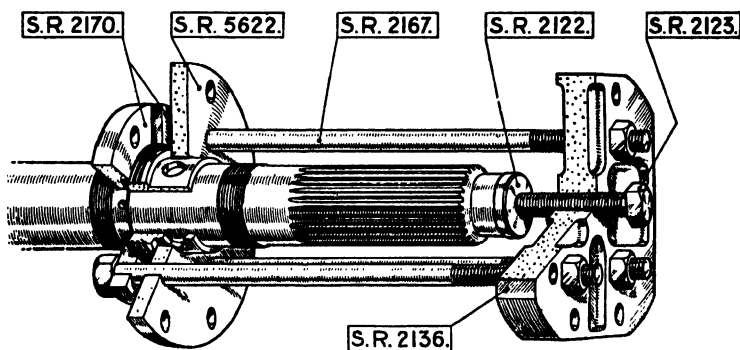


FIG. 42. Extractor for early type thrust bearing carrier.

Withdrawing the driving sleeve

144. The next component to be withdrawn is the driving sleeve. The extractor shown in fig. 43 should be built up and used as follows :—

- (i) Engage the shoes S.R.2131 fitted to the draw bolts S.R.2132 behind the skew gear of the driving sleeve so that their concave faces embrace the sleeve. Locate them in this position by passing the ring plate S.R.5622 over the ends of the draw bolts, allowing the plate to rest on the front end of the driving sleeve.

- (ii) Repeat operations (iii) and (iv) of para. 142, and, by screwing home the extractor bolt, withdraw the driving sleeve.

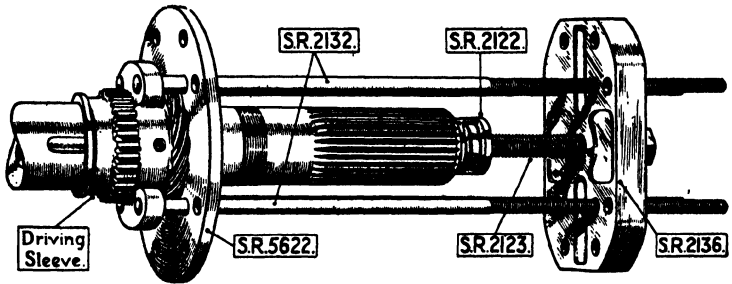


FIG. 43. Extractor for driving sleeve.

Removing the cam drum

145. Before withdrawing the cam drum, unscrew the nuts that secure the timing bracket, lift off the latter, and replace the nuts on the studs so as to avoid subsequent loss of the packing shims. Remove the split pins from the heads of the setscrews which retain the bearing keeper plate to the rear face of the cam bearer and remove the screws. Withdraw the tappets outwards through their guides to their fullest extent.

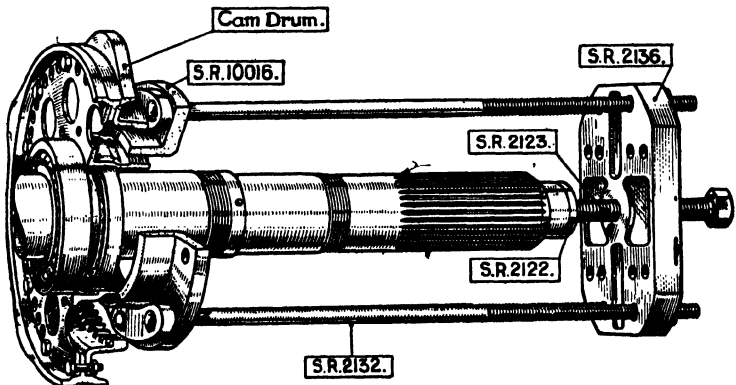


FIG. 44. Extractor for cam drum.

146. The extractor shown in fig. 44 should be used for withdrawing the cam drum as follows :—

- (i) Pass the draw bolts S.R.2132, used for removing the driving sleeve, through the holes in the adaptor S.R.10016 and screw the latter home on to the hub of the cam drum.

- (ii) Repeat operations (iii) and (iv) of para. 142, and, by screwing home the extractor bolt, withdraw the cam drum.

147. Remove the two halves of the bearing keeper plate from behind the universal bearing of the cam drum, lifting the crankshaft in the engine body to release them if necessary.

Removing the rear cover

148. Unscrew the bolts that retain the engine bearer to the erecting stand, screw an eyebolt into the end of the crankshaft and lift the engine clear of the stand by a sling taken through the eyebolt. Lower the engine on to two wooden baulks laid across two trestles so that the rear cover is uppermost. Remove the hand starter gear and engine speed indicator drive unit. Withdraw the magneto drive shaft and its bearing and housing. Unscrew the nuts securing the induction casing and rear cover and start the latter on its studs by a few light blows with a hide hammer. Remove the rear cover.

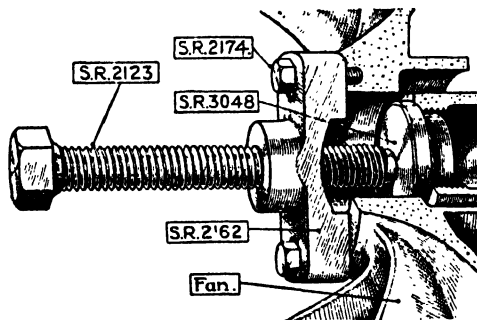


FIG. 45. Extractor for fan.

Removing the fan

149. Bend back the tab of the washer that locks the fan retaining nut and unscrew the latter, using the spanner S.R.2164. Using the extractor shown in fig. 45, withdraw the fan as follows:—

- (i) Fit the plug S.R.2162 or S.R.3048 in the end of the crankshaft.
- (ii) Secure the yoke S.R.2162 to the fan hub by means of the bolts S.R.2174.
- (iii) Screw the bolt S.R.2123 into the yoke and thereby withdraw the fan from its mounting. Care must be taken not to lose the fan gland or any of its four springs. The fan key should be removed from its keyway.

Removing the fan induction casing, crankshaft and connecting rod assembly

150. Screw four extractor bolts, S.R.24916, into their sockets in the fan induction casing and rotate them half a turn at a time to start the casing on its studs. Withdraw the casing and replace the retaining nuts and washers on their studs. Ensure that none of the 18 rollers of the rear main bearing are lost.

151. Remove the split pins that secure the nuts of the master rod bolts. Unscrew the nuts of two bolts that are diagonally opposite each other, using the long box spanner S.R.2177, drive out these bolts with a soft metal drift and remove the two remaining bolts. To part the cap from the master rod it may be necessary to ease the rod by tapping the shank of the rod lightly. Withdraw the two halves of the assembly to a position as close to the side of the engine body as possible.

152. Lift out the crankshaft, taking care not to lose any of the 16 rollers of the front main bearing. Remove the halves of the connecting rod assembly from the engine body.

CHAPTER V

OVERHAUL OF THE CYLINDER UNIT

Tools

153. The following tools are required when overhauling a cylinder unit.

Stores Ref. Section 36U.	Part No.	Description.	Classi- fica- tion.	Illus- trated in Fig.
4919	S.R.5596	*Valve spring depressing tool.	F	—
2052	S.R.28763	Valve spring depressing tool.	F	—
5031	G.T.2967	Hydraulic testing rig ..	J	46
6888	H.A.D.178/7	Gauge for inlet valve guide bore.	J	—
6889	H.A.D.178/8	Gauge for exhaust valve guide bore.	J	—
4956		EXTRACTOR FOR VALVE GUIDES, <i>consisting of</i> :—		
	S.R.5517	Head, for stud	J	47
	A.1.116E	Nut, $\frac{3}{8}$ in. B.S.F. ..		
	S.R.5518	Distance piece		
	S.R.5516	Stud		
	S.R.2157	Washer		
	S.R.5515	Spigot washer		
5024	S.T.10315	Reamer for valve guides	J	—
4921	S.R.5597	Valve grinding tool ..	F	48
5012	S.T.10314	Cutter for valve seats ..	J	49
2312	H.A.D.171	Valve spring test rig ..	J	—

Dismantling

154. When removed from the engine, the cylinder will be fitted with the valves, valve springs and rockers. Before removing the rockers from their brackets the end float of each rocker should be checked as described in para. 165. The rockers may then be removed as follows :—

- (i) Remove the split pin and nut securing the rocker fulcrum pin.
- (ii) Carefully drive out the fulcrum pin. A steel drift of slightly smaller diameter than the pin and having a tapped hole in one end so that it can be screwed on to the threaded portion of the pin is suitable for this operation.
- (iii) Remove the rocker and attach to it the two shims which are fitted on each side of it ; this will prevent their confusion or loss.

- (iv) With a bent drift, tap the bearings out of their housings in the rocker. The bearings cannot be tapped right through the housing because there is a central shoulder in the latter. Take care not to lose the small distance piece fitted between the inner races of the two bearings.

155. Remove the valves by placing the cylinder over a wooden billet having a domed end shaped to conform to the interior of the cylinder head. The billet should be screwed to the bench or held in a vice. Depress the valve springs by means of the tool S.R.28763 (single-handled) or S.R.5596 (double-handled) and remove the split cotter sleeve. If the tool S.R.5596 is used, it must be held so that the slot in its side clears the end of the rocker casing spring bolt. The circlips around the valve stems must be removed before the valves can be withdrawn from their guides.

156. The cylinder head locking ring, the cylinder head and the barrel must never be dismantled. It is unnecessary to remove the valve rocker brackets, rocker casings, or valve port flanges unless they are damaged or unless the cylinder bore is to be reground. The procedure for removing a rocker casing is as follows :—

- (i) Remove the rocker casing spring bolt by withdrawing the split pin.
- (ii) Unscrew the slotted nut securing the rear end of the casing to the valve port flange.
- (iii) Unlock the tab-washer and unscrew the nut securing the casing to the forked rod.
- (iv) Remove the slotted nut securing the forked rod to the cylinder head and withdraw the forked rod and casing.

When removing a valve port flange it is necessary almost to remove the rocker casing so that the casing clears the stud integral with the flange.

Examination

157. The components of the cylinder unit should be examined as described in A.P. 1464, Vol. I, Part 4, Sect. 4, Chap. 2, paras. 1 to 5 and 8 to 14. The bores of the inlet and exhaust valve guides should be checked by means of the plug gauges H.A.D. 178/7 and H.A.D. 178/8 respectively. As A.P. 1464, Vol. I, deals with examination from a general point of view only, there are some operations that are peculiar to this type of engine ; these operations, together with the methods of reconditioning components, are described below.

Hydraulic test on cylinder unit

158. After removal of the rockers, valves and cylinder barrel locking ring, each cylinder unit must be tested for security of the valve seats, sparking plug adaptors and gas starter non-return valve adaptor in the cylinder head, and for security of the cylinder head on the cylinder barrel. The test is effected by hydraulic pressure applied by means of the rig shown in fig. 46. The rig consists of a cast-iron adaptor secured by three bolts to an angle plate. The adaptor has an internal thread to enable the cylinder unit to be screwed into it. A large lock nut screwed on the outside of the adaptor has a 12° chamfer machined on one of its faces so that, when the cylinder has been screwed into the adaptor, the cylinder may be locked and the joint sealed against leaks by screwing the lock nut off the adaptor until the chamfer on the latter seats on the shoulder for the cylinder barrel locking ring around the cylinder barrel. Holes for the engagement of tommy bars are drilled around the lock nut. A filler cap, a drain cock and a union for a $\frac{3}{8}$ in. pipe are screwed into the adaptor and communicate with its interior. The inlet and exhaust ports are blanked off from the combustion chamber by dummy valves which are located in the valve guides and are drawn up on to the valve seats by internally threaded sleeves having tommy bars inserted through them. A cupped distance piece is interposed between each sleeve and the shoulder around each valve guide.

159. The cylinder to be tested must be fitted with dummy plugs in the sparking plug adaptors and the two dummy valves. These valves are marked "inlet" and "exhaust," and must be assembled in their appropriate ports. The sleeves securing the dummy valves must not be over-tightened. Having screwed the lock nut on to the adaptor as far as possible, screw the cylinder into the adaptor and position it so that the interiors of the ports can be inspected readily. Unscrew the lock nut until the chamfer around it bears around the shoulder on the cylinder barrel. After ensuring that the drain cock is closed, connect up the union on top of the adaptor to a pump capable of supplying hot water under a pressure of 600 lb. per sq. in. The hot water must be as near boiling point as possible. Remove the filler cap and fill the cylinder with hot water, replace the cap, ensuring that the fibre washer is in position, and tighten it with a spanner. Check all connections and plugs for security and apply the pressure. Using an inspection lamp, examine the interiors of the valve ports for leakage between the valve seats and the cylinder head. Examine the sparking plug adaptors and gas starter non-return valve adaptor for leakage. Any cylinders which fail in these tests must be rejected. The joint between

the cylinder head and cylinder barrel should also be examined. If a leak at this point is evident, the cylinder must be removed from the rig and the cylinder head tightened on the cylinder barrel as described in para. 130. The cylinder unit must then be retested. If the leak cannot be remedied, the cylinder unit must be rejected.

Removal and replacement of valve guides

160. Defective valve guides should be withdrawn by means of the extractor shown in fig. 47. The tool is to be built up and used as follows :—

- (i) Insert the draw spindle S.R.5516 through the bore of the guide to be withdrawn from the interior of the cylinder. Engage the spigot on its head in the bore of the guide.
- (ii) Pass the sleeve S.R.5518 or S.R.15644 over the head of the guide.
- (iii) Thread the collar S.R.5515 over the end of the draw spindle and engage its shoulder in the bore of the sleeve.
- (iv) Pass the washer S.R.2157 over the end of the draw spindle and screw on the nut.
- (v) Screw the nut home and thus withdraw the guide from its socket.

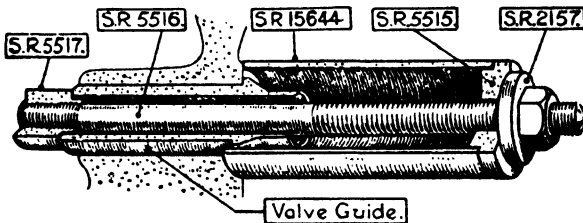


FIG. 47. Extractor for valve guides.

161. Replacement guides may be driven into their sockets with a hide hammer after their shanks have been coated with tallow. Guides having oversize shanks are available for insertion in sockets which have "grown." The diameter of the shanks of both inlet and exhaust oversize valve guides increase by increments of 0.002 in. up to 0.010 in. ; oversize guides are marked "X", "Y", "Z", "W", or "V", those marked "X" being 0.002 in. oversize, "Y", 0.004 in. oversize, and so on. Replacement guides must, after being fitted, be reamed with the hand reamer S.T.10315, which is suitable for both inlet and exhaust guides.

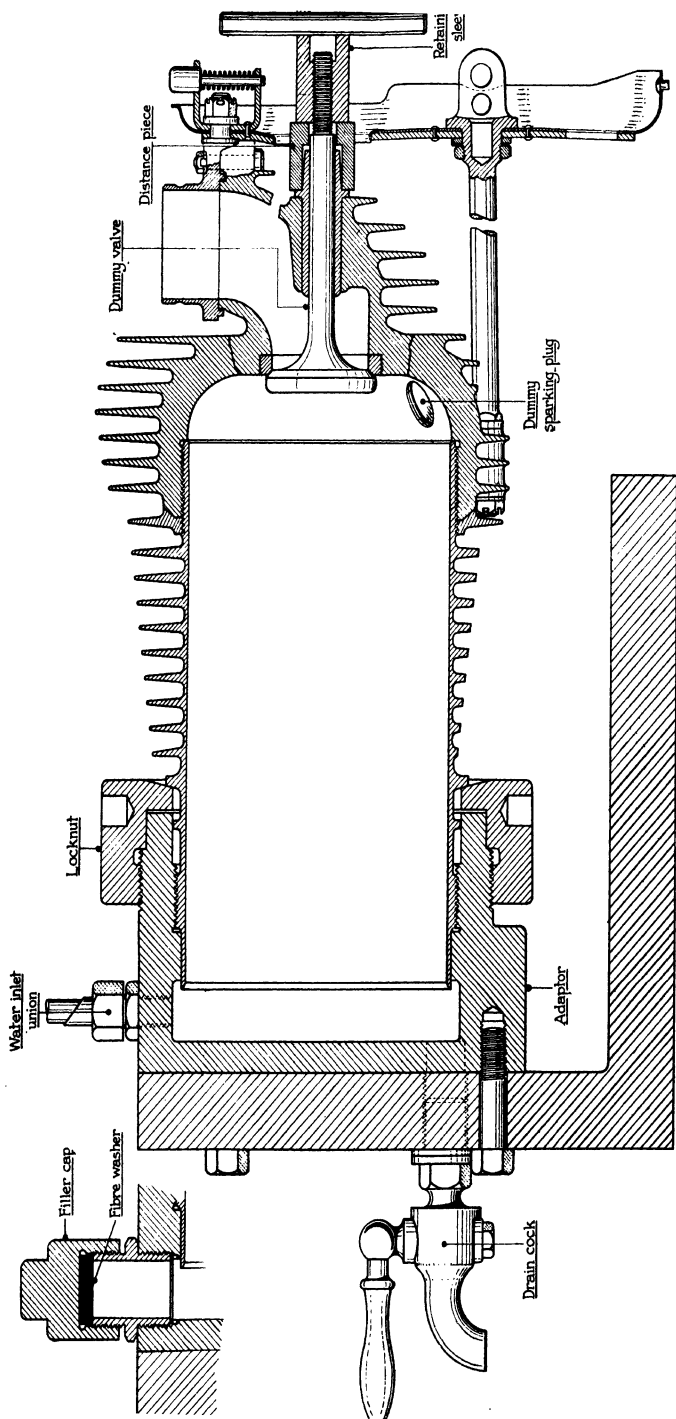


FIG. 46. HYDRAULIC TEST RIG FOR CYLINDER UNIT

Reconditioning of valve seats

162. If the valve seats are found to be in good condition on examination as described in A.P. 1464, and if the original valves and guides are retained the seats may be reconditioned by grinding first with a spare valve kept for the purpose and finally with the valves with which they are to be fitted. The spare valves should be checked frequently to ensure that its face is true and at the correct angle to the axis.

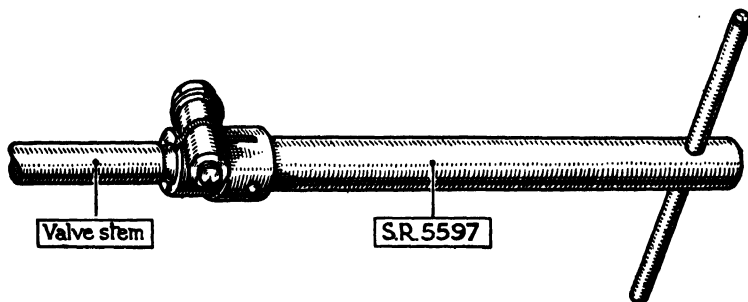


FIG. 48. Valve grinding tool.

163. A valve grinding tool S.R. 5597 (*see* fig. 48) is available for gripping the stem during regrinding. If the condition of the surface of the seat renders this method of reconditioning impracticable, or if new valve guides, valves or refaced valves are to be fitted, the seat must be refaced. Before refacing any seats, any faulty valve guides must be extracted and new ones fitted. Refacing is effected with the tool illustrated in fig. 49 as follows :—

- (i) Insert the cutter spindle, with the cutter attached, through the valve guide.
- (ii) Place an inner spring cup over the head of the valve guide and an outer valve spring upon it.
- (iii) Place an outer spring cup upon the spring and pass the retaining collar supplied with the cutter over the end of the spindle.
- (iv) Thread a sufficient number of washers over the end of the cutter spindle to ensure a reasonable compression of the spring when the tommy bar is inserted in its socket.
- (v) Insert the tommy bar in its socket.
- (vi) Give the cutter a few turns in a clockwise direction.

- (vii) Dismantle the cutter and inspect the seating ; if necessary repeat the above operations. Measure the diameter of the seat for conformity to the limits specified in A.P. 1287, Vol. II, Part 2, by the method described in A.P. 1464, Vol. I.
- (viii) Grind the valve to its seating.

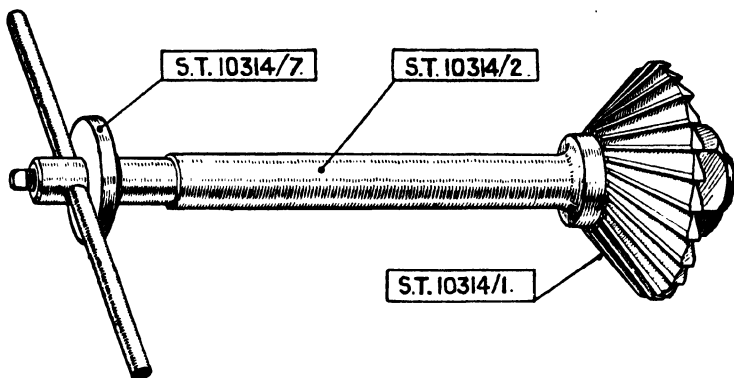


FIG. 49. Cutter for valve seats.

Valve spring test rig

164. All valve springs must be tested by means of the spring testing rig H.A.D. 171 or the rig described and illustrated in A.P. 1464, Vol. I. Both rigs are identical in principle ; the construction of the rig H.A.D. 171 is the simpler of the two. When using the rig H.A.D. 171 the spring to be tested must be inserted between the pegged loading plate and the bracket, a suitable test weight being attached to the loading plate through the loading hook. When making up the test weights due allowance must be made for the weights of the loading plate and loading hook. When the spring is under compression, the length between the loading plate and bracket must be checked with the appropriate gauge. If the gauge cannot be inserted, the spring must be rejected. Two gauges are supplied with the rig, one for the Lynx IV* and one for the Lynx IV (Mod.) and IV ; care must be taken to use the larger of the gauges for Lynx IV* springs.

Examination of valve rockers

165. Examine the valve rockers for the following defects :—

- (i) End float in bearings. This should be checked before the rockers are removed from the bracket by means of the rig shown in fig. 50. The rig should be used as follows :—
 - (a) Pass the pin (B) through the sleeve (A) and turn the two components so that the holes

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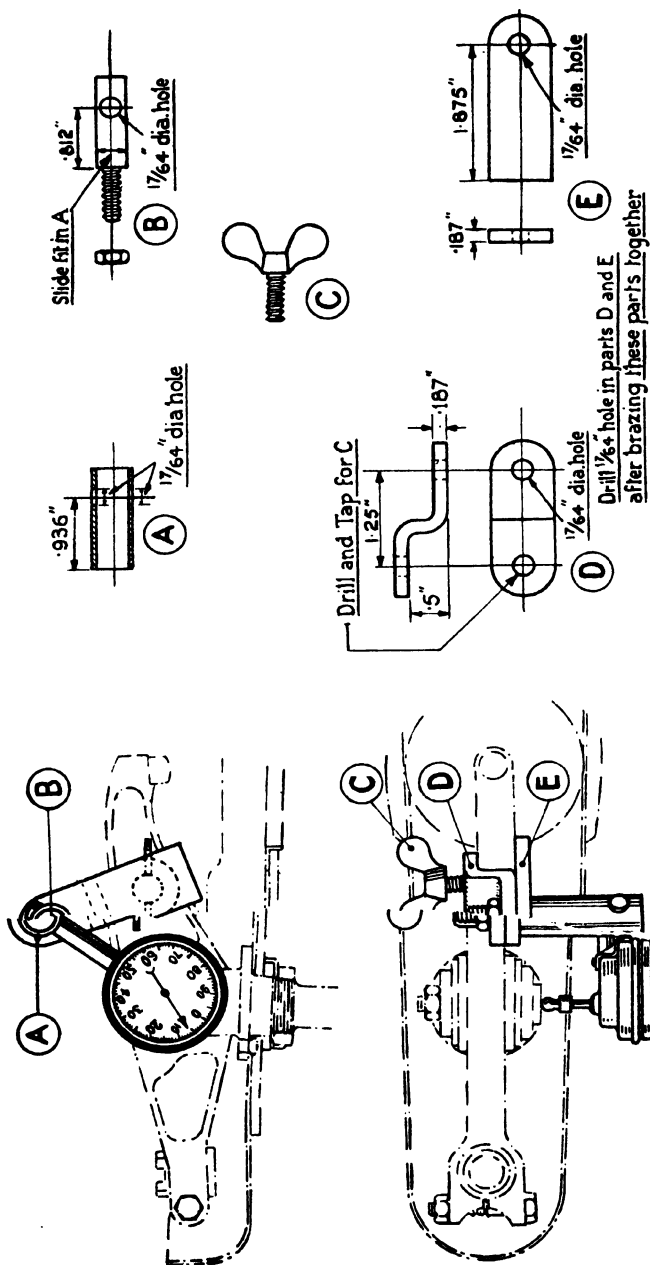


FIG.50, RIG FOR TESTING VALVE ROCKER END FLOAT

through them are in registration. Pass the mounting sleeve of a dial indicator through the holes in the pin and sleeve. Insert the threaded end of the pin into the hole in the bracket, built up from items (D) and (E), and secure it lightly with a nut.

- (b) Fit the bracket to the valve rocker as shown in fig. 50, securing it by screwing home the wing-bolt (C).
- (c) Set and lock the indicator so that its actuating spindle bears normally upon the end of the rocker fulcrum pin, and a deflection of the needle is registered.
- (d) Grasping the rocker at each end, slide it through its range of end float and note the deflection of the needle.
- (ii) Fit of outer races of bearings in housings.
- (iii) Bending of rockers.
- (iv) Wear of thrust pads. Worn pads must be removed from the screwed sockets and new ones substituted.
- (v) Wear of striking pins. Worn pins must be renewed.

166. After examination, the rockers should be assembled by tapping one of the bearings into the housing, turning the rocker over, placing the distance piece for the inner races in the bearing housing, and tapping the second bearing into place. The bearings must be packed with grease (Stores Ref. 34A/54) before assembly.

Assembly of cylinder unit

167. A completely dismantled cylinder should be assembled in the following sequence :—

- (i) Fit the valves and springs, coating all working surfaces with oil.
- (ii) Fit the valve port flanges. The joints between the flanges and the valve port faces should be made with liquid jointing compound. Lock the retaining nuts with tab-washers.
- (iii) Mount the inner halves of the rocker casings on the flanges and attach them to the latter by screwing on the retaining nuts a few turns ; do not tighten these nuts at this stage.
- (iv) With the X-shaped bracing assembly in position, thread each of the forked rods through the casing, the upper lug of the bracing assembly, the tab-washer and nut for securing the casing to the rod,

the lower lug of the bracing assembly, and the cylinder head socket. Ensure that the forked rod is correctly aligned so that the dowel on the underside of the fork enters the hole in the casing. Fit the plain washer and slotted nut securing the rod to the cylinder head and tighten and split pin the nut. Screw on, tighten and lock the nut securing the casing to the rod.

- (v) Tighten and split pin the nuts securing the casings to the flanges. Fit the rocker casing spring bolts.
- (vi) Place the large and small diameter shims on each side of the rocker bearing housing and insert the assembly between the cheeks of the forked rod. The large diameter shims must be fitted next to the bearings.
- (vii) Line-up the assembly with a pilot having a lead filed at one end. Fit the rocker fulcrum pin, screw home its nut and split-pin it in position. When a replacement valve rocker is being fitted, the side clearance between its inner races and the cheeks of the forked rod must be checked before fitting the rocker fulcrum pin and such washers fitted as will most nearly take up the clearance and result in a minimum of distortion of the forked rod. The larger diameter washers are 0.009 in. thick, whilst the smaller diameter washers are supplied in thicknesses of 0.009 in. and 0.014.
- (viii) Grease the valve rockers, using grease to Stores Ref. 34A/54.

CHAPTER VI

OVERHAUL OF THE PISTONS AND CONNECTING RODS

Tools

168. The following tools and gauges are available.

Stores Ref. Section 36U.	Part No.	Description.	Classifi- cation.
6886	H.A.D.178/5	Gauge for bore of wrist pin bush ..	J
6887	H.A.D.178/6	Gauge for bore of gudgeon pin bush.	J
6884	H.A.D.178/3	Gauge for bore of eye in gudgeon pin end of floating bush type connecting rod.	J
6885	H.A.D.178/4	Gauge for bore of eye in wrist pin end of floating bush type articu- lated rod.	J
6896	H.A.D.179/1	Mandrel for master rod bearing ..	J
6897	H.A.D.179/2	Mandrel for master rod bearing ..	J
6898	H.A.D.179/3	Mandrel for eye at gudgeon pin end of floating bush type con- necting rod.	J
6899	H.A.D.179/4	Mandrel for eye at wrist pin end of floating bush type articulated rod.	J

Dismantling

169. When removed from the engine the pistons will be fitted with the rings and the master rod with the articulated rods. No difficulty will be experienced with the removal of the rings from the pistons. Before the articulated rods can be removed, the wrist pins must be withdrawn. After removal of the big-end bolts, the four notched wrist pins may be tapped out by means of a hammer and soft drift. The two stepped pins must be pressed out by means of an arbor press after removal of their retaining circlips. The stepped pins must, of course, be pressed out from their smaller ends, which may be distinguished by the spigots around them. Care must be taken not to damage the sealing plugs in the ends of the pins, and if the master rod is held in a vice whilst the notched pins are tapped out, suitably shaped wooden blocks must be inserted on either side of the web of the shank of the rod, which should be gripped between these blocks. As the fit of the wrist pins in their sockets is most important, it is advisable to note the fit of each pin as it is tapped out, and also to record the socket from which each pin is removed so that the latter may be re-assembled in the same position.

Examining

170. The pistons and connecting rods should be examined as described in A.P. 1464, Vol. I, Part 4, Sect. 4, Chap. 2, paras. 19 to 25. The bores of the fixed bushes in the gudgeon pin ends of the master and articulated rods and in the wrist pin ends of the articulated rods should be checked by means of the plug gauges H.A.D.178/6 and H.A.D.178/5 respectively. The plug gauges H.A.D.178/3 and H.A.D.178/4 are necessary for checking the bores of the eyes for the floating bushes in the gudgeon and wrist pin ends of the articulated rods in the floating bush type of assembly. The master and articulated rods should be checked for alignment as detailed in paras. 22, 26 and 27 of Chap. 3 of the same section. In addition to the tests to determine twist and lack of parallelism between the big-end and the gudgeon pin end of the master rod, and between the gudgeon pin end of each articulated rod and the big-end of the master rod, two additional tests are necessary in order to determine whether the rods conform to the limits specified in A.P. 1287, Vol. II, Part 2.

171. The first of these tests is to determine the error of alignment between the big-end and each pair of wrist pin sockets in the master rod due to twist and lack of parallelism. The error due to twist is measured when the master rod is set up so that the line joining the axis of a mandrel in the big-end and the axis of a mandrel inserted in a pair of wrist pin sockets is parallel to the surface table. The error due to lack of parallelism is measured when the rod is set up so that the line through the axis of the two mandrels is normal to the surface table.

172. The second test is to determine the twist and lack of parallelism between the wrist and gudgeon pin ends of each articulated rod, and is effected in the same manner as the corresponding test on the master rod.

173. During the alignment tests the master rod should be mounted upon one of the mandrels H.A.D.179/1 or H.A.D. 179/2. These mandrels are bored for their entire length and are ground in steps to four different diameters. Thus each may be used for four sizes of big-end bearing. In addition, the mandrels are reduced in diameter at their ends to enable them to be mounted in V-blocks. The diameter of the first mandrel, H.A.D.179/1, increases from 2.472 in. to 2.484 in. by increments of 0.004 in., whilst that of the second increases from 2.488 in. to 2.501 in. by three increments of 0.004 in. and one of 0.005 in. Two mandrels, H.A.D.179/3 and H.A.D.179/4, are ground to diameters of $1.436\frac{3}{4}$ in. and $0.999\frac{1}{4}$ in. respectively and are suitable for alignment tests on the floating bush type of connecting rod assembly only.

The larger mandrel fits the eyes for the floating bushes in the gudgeon pin ends of the connecting rods, whilst the smaller fits the eyes for the floating bushes in the wrist pin ends of the articulated rods.

Fitting new master rod bearings

174. Bearing shells which are faulty from whatever cause may not be remetalled but must be renewed. Two sizes of replacement bearing shell, differing in the thickness of white metal, are available ; one is of standard size in length and bore, and the other is oversize in length and undersize in bore. The latter must be bored and faced to suit the crankpin on which it is to be fitted.

175. Fig. 51 shows the jig, boring bar, etc., that are available for boring and facing bearing shells. The machining of the bore and end flanges of the bearings is effected by cutters, suitable for the operation in hand, mounted radially in a socket in the boring bar (9). The bar is supported in bushes (4) and (17) in a cast-iron body (20) in which the bearing is retained by a cap (6). The bar and cutter are fed through the bearing automatically as the bar is turned, turning being effected by a hand wheel mounted on a square at one end of the bar. The feed is effected by a lead screw (33) which engages a nut (8) in that end of the boring bar further from the hand wheel. A very slow feed is effected by causing the lead screw to turn in the same direction as, but at a slower speed than the bar. This movement of the lead screw is effected as follows by a form of back gear mounted in a bracket (26) at one end of the body.

176. The end of the boring bar which is operated by the lead screw is keyed to the flanged bush (4) which is retained against end travel in its housing by a retaining plate (1) screwed to the end of the body. The bush, which is free to turn in its housing, has screwed and pinned to its outer end a spur gear wheel (2) through which the plain portion of the lead screw (33) passes freely. The spur gear wheel engages one end of a compound gear wheel (27) carried on a spindle in the back gear bracket (26). The other end of the compound gear wheel meshes with a second spur gear wheel (31) keyed to the lead screw beyond the wheel (2). It will be seen, therefore, that when the boring bar is turned, the bush (4) is also turned and drives the compound gear wheel through the wheel (2) ; the rotation of the compound gear wheel transmits the drive to the lead screw through the wheel (31).

177. The lead screw is prevented from end movement in the bush (4) by two thrust washers (34) fitted one on each side of a shoulder on the lead screw and trapped in a recess in the bush at the back of the spur gear wheel (2). The handle (29)

is used for traversing the bar through the bush (4) after the compound gear wheel (27) has been swung out of engagement with the wheels (2) and (31) by partly rotating the spindle on which it is mounted. Rotation of the compound gear wheel spindle, which has eccentrically-turned ends, is effected by the small lever (28).

178. Two types of cutter are used with the boring bar, one for boring, and one for facing and radiusing the ends of the bearing. The cutters are received in a socket drilled radially in the bar, and are fed up to the surface to be machined by a grub screw (11); a second grub screw (12) prevents the cutter from turning or from advancing out of the socket. It is of advantage to drill and tap the boring bar as shown in fig. 52 as this will enable the radius cutter to be applied to the right-hand end of the bearing with the bar as well supported in the bush (4) as when it is applied to the left-hand end. The boring cutter may be set to produce any desired bore by being advanced up to a form of depth gauge (24). The gauge consists of the spindle, barrel and clamp nut of a micrometer, and is fitted in one side of the body. Two methods may be adopted for obtaining the desired length of the bearing whilst radiusing and end facing. The first method is applicable for bearings for use with standard length crankpins only, and when this method is adopted the gauges (14) and (15) of fig. 51 are used. When using these gauges, the left-hand end of the bearing is first radiused and faced until the gauge (15) can be inserted between the end flange and the recess in the housing for the bush (4). The right-hand end of the bearing is next machined so that the gauge (14), when set to give the desired length, can be slipped over the two end flanges. The second method of obtaining the desired length of bearing is applicable for bearings for use with crankpins of standard length or with over-length crankpins. When adopting this method, one end of the bearing is first machined so that feelers of a thickness dependent on the desired length of bearing can be inserted between the end flange and the slot in the gauge detailed in fig. 52 when the latter is held up against the face of the cap which retains the bearing in the jig. The other end of the bearing is next machined so as to bring the bearing to the desired length as measured with a micrometer. The gauge is to be made up by units.

179. No device is provided on the jig to indicate, when facing the ends of the bearing, the amount of travel that is transmitted to the boring bar by any given movement of the handle (29) fitted to the lead screw. Fig. 52 gives details of a device to be fitted to the lead screw and back gear bracket to provide this indication. Each graduation on the disc represents a 0.001 in. travel of the boring bar.

180. The cap (6) of fig. 51, by which the upper portion of the bearing shell is retained to the lower, is secured to the jig by four studs and is registered on the jig by two dowels (23). The fit of the dowels is such as to render difficult the removal of the cap by hand. Consequently two plungers (18), operated by cams (22), shaft (21) and lever (25), are provided to raise the cap clear of the jig after the retaining nuts have been removed. The fit of the halves of the bearing in the jig and cap is such that the halves of the bearing may not easily be removed by hand. To facilitate the removal of the parts in question, the extractor tools (3) and (5) are provided. The hook tool (3) is used for removing the lower portion of the bearing from the jig, the hooked portion being engaged around the flange and the tool as a whole jerked upwards. The tool (5) is used for removing the upper portion of the bearing from the cap, the cap being reversed and placed between the sides of the tool, so that the end flanges of the bearing rest in the V's; the cap is then pressed downwards and the bearing removed.

Boring replacement master rod bearings

181. (i) Remove the nuts which retain the bearing housing cap to the body, raise the lever which operates the camshaft until the cap has been lifted clear of the dowels and then remove the cap.

(ii) Remove the tool from the boring bar (if fitted) after slackening the grub screw (12) which clamps it in position.

(iii) Swing the lever (28) fitted to the back gear shaft so as to disengage the gear and then turn the handle at the end of the lead screw until the lead screw disengages the boring bar, after which remove the bar and the loose bush (17) in which its operating end is supported.

(iv) Fit the lower portion of the bearing to be bored in the housing in the body and the upper portion in the cap, so that when the cap is replaced correctly on the body the batch numbers stamped on the edges of the bearing end flanges are next to one another. Do not as yet replace the cap on the body. Next lubricate the bar and the two bushes in which it is supported. The keyed bush (4) must be lubricated externally through the nipple fitted to the housing.

(v) Slide the loose sleeve (17) over the squared end of the boring bar and insert the bar in the body, being careful to engage the keys correctly in the keyways in the bush (4) which remains in the jig. As soon as the end of the bar has been entered into the mouth of the bush last mentioned, slide the loose bush along the bar and into its housing in the body, turning it so that its flange first passes and is then locked by the large screw (16) in the end of the body.

(vi) Next advance the bar through the two bushes until its end comes in contact with the end of the lead screw and then draw it fully home into the bush (4) by turning the handle at the end of the lead screw.

(vii) Fit the bearing cap and upper portion of the bearing to the body; owing to the dowels being of different sizes, it can only be fitted in the correct position. After seeing that the batch numbers on the edges of the end flanges of the two portions of the bearing shell lie next to each other, fit the cap retaining nuts and draw them up tight.

(viii) Screw the micrometer depth gauge home until the end of the spindle touches the boring bar and make a note of the reading. Check the diameter of the boring bar with a micrometer, then set the spindle of the depth gauge back by half the difference between the diameter of the bar and the desired bore of the bearing, and lock it with the locking ring.

(ix) Fit the boring tool in its socket in the boring bar and then traverse the bar until the tool is about to reach the end flange of the bearing. Adjust the grubscrew (11) which feeds the tool up to its work until the tool will take a cut of a depth not exceeding 0.010 in. and then lock the tool by tightening the second grub screw (12).

(x) Traverse the bar back again until the tool is opposite the end of the depth gauge and carefully turn the bar so that it can be ascertained that the tool will produce a bore less than the desired finished size. If the tool has been set too far out it must be re-adjusted so that it will clear the end of the depth gauge by an amount just sufficient to provide a fine finishing cut of not more than 0.003 in. after the preliminary boring cut has been made. Every care must be exercised to prevent the tool fouling and damaging the end of the depth gauge.

(xi) Having thus set the tool for the preliminary cut, engage the compound gear wheel of the back gear with the wheels on the lead screw.

(xii) Mount the hand wheel on the end of the boring bar and commence turning it in an anti-clockwise direction, so as to feed the tool through the bearing.

(xiii) After the tool has been fed right through the bearing, slacken the grub screw (12) which secures it in the bar and remove it. Disengage the back gear and traverse the boring bar back to its original position and set the tool to take either a further rough cut or the finishing cut. The finishing cut should not exceed 0.003 in. in depth.

(xiv) Having completed the finishing cut, remove the boring tool from the bar, traverse the bar back to the original position and unscrew the spindle of the depth gauge till its end is flush with the knurled locking ring.

(xv) Fit the radiusing tool (19) to the bar so that it may be used to work on the end of the bearing further from the hand wheel and slack back the grub screw (11) which feeds it up to its work.

(xvi) Traverse the bar until about 0.05 in. of the parallel lead to the inner edge of the tool is located inside the bore of the bearing and then slide the tool outwards by turning the feed screw (11) until the parallel lead just touches the finished bore of the bearing. Lock the tool in this position with the second grub screw (12), rock the bar and note whether the parallel lead to the tool is taking a cut. The tool should be so adjusted that whilst the cutting edge is in contact with the bore of the bearing, no metal is removed when the bar is turned.

(xvii) Having set the tool as described above, first spring the tool by about 0.001 in. into the whitemetal surface of the bearing flange by turning the handle (29) and then, after removing the handle, turn the hand wheel in an anti-clockwise direction until the tool ceases to take a cut. As soon as the tool ceases to cut, stop turning the hand wheel and once more spring the tool into the end of the bearing, after which continue turning the hand wheel. Repeat these operations until the tool is taking a cut over the whole of the end of the bearing. When this has been achieved, turn the boring bar so that the tool is undermost but do not interfere with the setting of the handle (29).

(xviii) Depending on which method of measurement is being adopted, attempt to enter the gauge (15) of fig. 51 between the flange of the bearing and the recess on the housing for bush (4), or, hold the gauge shown in fig. 52 up to the end of the bearing cap and, by inserting feelers through the slot in the gauge, check the clearance between the end of the bearing and the face of the gauge (the cap must first be cleaned of all swarf). When adopting the first method of measurement the amount of metal that must be removed to enable the gauge to enter must be estimated by the eye, but when using the second method, the amount of metal to be removed can be definitely calculated by subtracting the measured clearance between the gauge and bearing flange

from the desired clearance. The amount of metal to be removed from the bearing end flange will then be given by either of the expressions.

$$m = S + \frac{1}{2}(x - l) - C \text{ or}$$

$$m = (S + \frac{1}{2}x) - \left(\frac{l}{2} + C\right) \text{ where}$$

m = depth of metal to be removed.

S = depth of the lip of the gauge shown in fig. 52.

x = breadth of the cap (15). This must be measured with a micrometer.

l = desired length of bearing.

C = measured clearance between gauge and bearing flange.

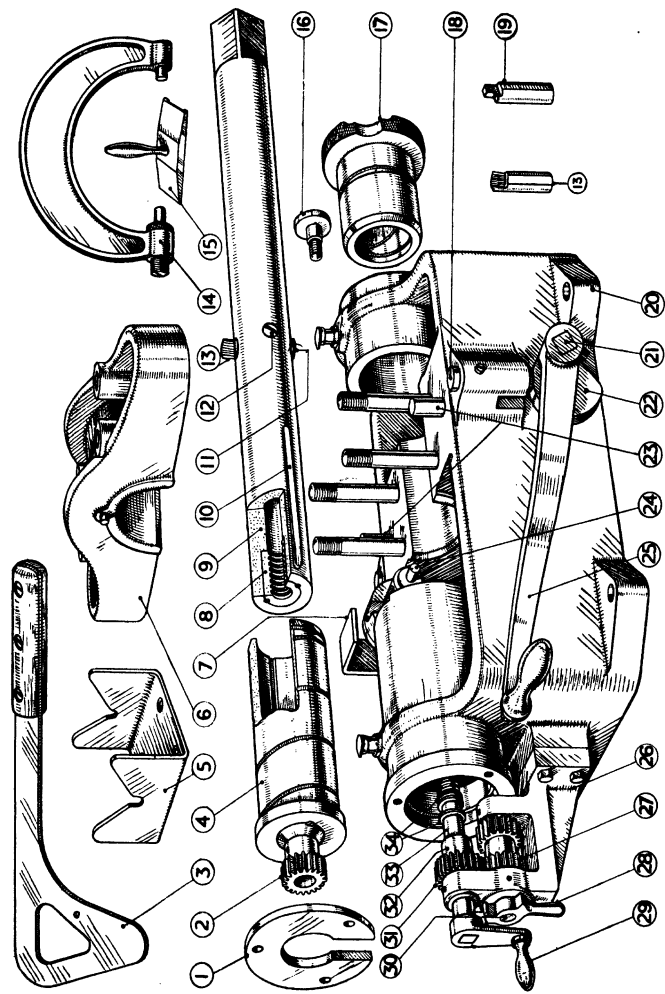
The expression $(S + \frac{1}{2}x)$ is a constant for the base and gauge.

(xix) Having determined the amount of excess metal on the bearing end flange, proceed to remove it by a series of cuts not exceeding 0.002 in. in depth. The depth of cut may be gauged by the number of graduations on the hand wheel that are traversed past the pointers on the back gear bracket when the lead screw is turned by the handle (29) when springing the tool into the bearing end flange. Each graduation on the disc on the lead screw represents a traversing movement of 0.001 in. on the part of the boring bar. After applying the cut, the handle (29) must be removed from the end of the lead screw.

(xx) Commence turning the boring bar and continue turning it until the tool ceases to cut. Before preparing to take the next cut check the amount of metal removed, using the gauge. Continue the above operations, arranging the depth of cuts so that a finishing cut not exceeding 0.001 in. in depth may eventually be taken. When the correct amount of metal has been removed, the clearance between the bearing end flange and the inner face of the gauge will be $(S + \frac{1}{2}x) - \frac{l}{2}$.

(xxi) Having completed the finishing cut, remove the radius cutter and traverse the bar so that the cutter may be fitted in the second socket beyond the further end of the bearing and then repeat operations (xvi) and (xvii) so as to machine that end of the bearing.

(xxii) Measure the length of the bearing with a micrometer and note the amount of metal that must be removed from the further end to bring the bearing to the desired length.



1. RETAINING PLATE FOR 4.
2. GEAR WHEEL FIXED TO 4.
3. EXTRACTOR FOR BEARING LOWER HALF.
4. FEED BUSH FOR 9.
5. EXTRACTOR FOR BEARING UPPER HALF.
6. BEARING RETAINING CAP.
7. GUARD FOR 24.
8. NUT FOR 33.
9. BORING BAR.
10. KEYS FOR 4.
11. ADJUSTING SCREW FOR 13.
12. CLAMPING SCREW FOR 13.
13. BORING TOOL.
14. BEARING LENGTH GAUGE.
15. FACING GAUGE.
16. POSITIONING SCREW FOR 17.
17. LOOSE BUSH FOR 9.
18. PLUNGER FOR REMOVING 6.
19. FACING TOOL.
20. BODY.
21. CAMSHAFT.
22. CAM.
23. DOWELS FOR 6.
24. MICROMETER DEPTH GAUGE FOR SETTING 13.
25. LEVER FOR 21.
26. BRACKET FOR BACK GEAR.
27. COMPOUND GEAR WHEEL.
28. BACK GEAR THROW-OUT LEVER.
29. HANDLE FOR 27.
30. SPINDLE FOR 27.
31. GEAR WHEEL FIXED TO 33.
32. DISTANCE PIECE.
33. LEAD SCREW.
34. THRUST WASHERS.

FIG. 51. BIG END BORING EQUIPMENT.

(xxiii) Spring the tool up to the end of the bearing preparatory to taking a cut and then carry out operation (xx), but instead of checking the amount of metal removed after each cut as instructed in that operation, check the overall length of the bearing with a micrometer.

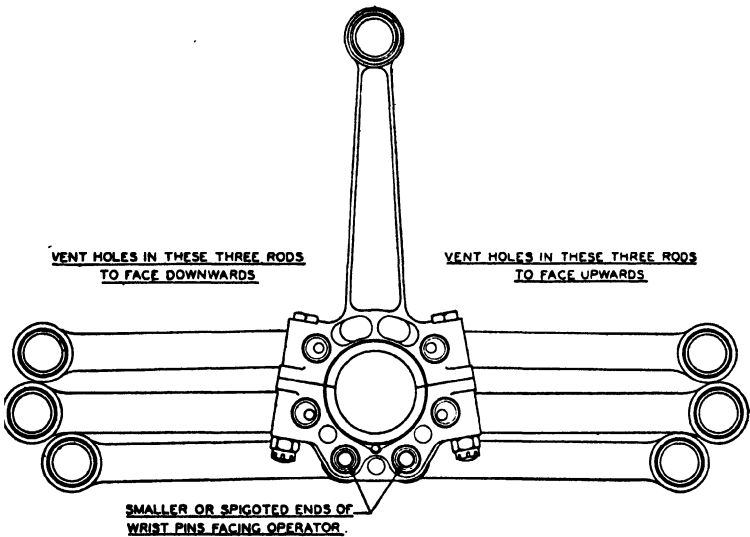


FIG. 53. Assembly diagram for connecting rods.

Assembling

182. Having examined the components of the connecting rod unit, they may be assembled as instructed below. Fig. 53 shows the relationship between the components after assembly, and it is essential that they are positioned as shown.

183. The master rod, with the cap bolted to it, should first be held by its shank in a vice, exercising the precaution of clamping it between wooden blocks, as described in para. 169. The rod should be positioned so that the two larger housings for the stepped wrist pins face the operator. One of the stepped wrist pins, having been cleaned and coated with oil, must then be inserted, smaller or spigoted end first, into its appropriate socket in the cap half of the rod, so that one of the oil holes in the pin will coincide with the oil hole in the cap when the pin is fully home. Next insert the wrist pin end of the appropriate articulated rod, facing the correct way, between the cheeks of the cap and, using a hide hammer, tap the wrist pin as far home as it will go easily, that is, until the stepped-up diameter encounters the larger socket. Remove the rod from the vice and insert a circlip in the smaller socket. Examine the projecting portion

of the wrist pin to ensure that the latter has not turned, in which case the oil holes in the pin and cap will not coincide. Press the wrist pin home by means of an arbor press, taking care not to press it beyond the central position ; it must not bear on the circlip fitted in the smaller socket. Finally, fit the circlip in the larger socket. The second articulated rod and stepped wrist pin are fitted identically.

184. Before fitting the remaining articulated rods, the master rod bolts must be removed and the cap separated from the rod. The procedure to be adopted is similar to that described above, except that the notched wrist pins may be tapped right home. As previously stated, the fit of the notched pins in their sockets is of primary importance ; they must be a light drive fit, as excessive interference will cause picking-up between the pins and the sockets and slackness will cause distortion of the rod, resulting in the formation of high spots on the master rod bearing. The pins must be inserted so that the notches will line up with the master rod bolt holes after assembly. For this purpose, a tapered bolt of the same diameter as the master rod bolts should be tapped into the bolt holes after the pins have been tapped home.

185. All the articulated rods having been fitted, insert the appropriate bearing shells in their housings in the master rod and cap. The shell to be fitted in the cap has a number marked on one of its flanges close to the lugs which engage the pegs fitted in the cap. One side of the cap is marked similarly, close to the peg. The shell is to be fitted so that these numbers are adjacent. Each shell has a number stamped on the side of the flange around one end. The rod portion of the shell must be so assembled in the rod that when the cap is offered up correctly to the rod, the numbers lie next to each other.

CHAPTER VII

OVERHAUL OF THE CRANKSHAFT, FRONT COVER AND ENGINE BODY**Tools**

186. The following tools from the engine tool kits may be required :—

Stores Ref. Section 36U.	Part No.	Description.	Classi- fica- tion.	Illus- trated in fig.
4988	S.R.6192	Extractor for crankshaft front plug.	W.2	54
		EXTRACTOR FOR INNER RACE OF REAR MAIN BEARING, <i>consisting of :—</i>		
4948	S.R.2127	Draw bolt (4 off) ..	W.1	55
4949	S.R.2136	Yoke plate (1 off) ..		
4955	S.R.2128	Draw plate (1 off) ..		
4959	S.R.2126	Plug for rear end of crankshaft (1 off)		
4963	S.R.2125	Ring plate (1 off) ..		
4964	S.R.2123	Extractor screw (1 off) ..		
		EXTRACTOR FOR CAM DRUM BEARINGS, <i>consisting of :—</i>		
4942	S.R.5907	Adaptor (2 off) ..	W.1	56
4944	S.R.2132	Draw bolt (2 off) ..		
4949	S.R.2136	Yoke plate (1 off) ..		
4958	S.R.2122	Plug for front end of crankshaft (1 off).		
4964	S.R.2123	Extractor screw (1 off) ..		
		EXTRACTOR FOR INNER RACE OF FRONT MAIN BEARING, <i>consisting of :—</i>		
4947	S.R.2121	Draw bolts (4 off) ..	W.1	57
4949	S.R.2136	Yoke plate (1 off) ..		
4954	S.R.2120	Draw plate (1 off) ..		
4958	S.R.2122	Plug for front end of crankshaft (1 off).		
4962	S.R.2119	Ring plate (1 off) ..		
4964	S.R.2123	Extractor screw (1 off) ..		
4996	S.R.6185	Tubular drift for front main and cam drum bearings.	W.2	—
4996	S.R.6686	Tubular drift for cam drum.	W.2	58
4994	S.R.6182	Tubular drift for crankshaft front steady bearing.	W.2	—
5000	S.T.10238	Tool for refacing cylinder barrel locking ring seatings on engine body.	W.2	59

Examination of the crankshaft

187. The crankshaft, dismantled to the extent attained on its removal from the engine, should be mounted in V-blocks on the inner race of the rear main bearing and the outer race of the cam drum rear bearing. The V-blocks must be of sufficient height to enable the crankshaft to be rotated, and one of the blocks must be packed up so that the axis of the crankshaft is parallel to the surface table. The amount that the V-block must be packed up may be determined by measuring, with a micrometer, the diameters of the inner race of the rear main bearing and of the outer race of the cam drum rear bearing, halving them to obtain the radii, and then subtracting the smaller from the greater. The heights may be measured by means of a height gauge and checked with a dial indicator mounted on a large scribing block.

188. The shaft must then be rotated in the V-blocks and dial indicator readings taken at the extreme front end in order to determine the lack of truth; the latter, if existent, must be within the stipulated limit, and is obtained by halving the indicator reading.

189. The shaft is next turned so that the crankpin is at B.D.C., and indicator readings are taken at points positioned on the crankpin as called for in A.P. 1287, Vol. II, Part 2. The shaft is then rotated through 90° and further readings are taken. Care must be taken to ensure that the actuating plunger of the indicator is clear of the oil groove.

190. Examine the shaft as detailed in A.P. 1464, Vol. I, Part 4, Sect. 4, Chap. 2, para. 26. Remove the crankpin sealing plug by removing the split pin, nut and cap. The screwed plug in the front crankweb must not be removed; its function is to prevent the sealing plug from turning. Remove all sediment from the bores of the crankpin and sealing plug. Wash all oilways through with paraffin under pressure and dry them by means of compressed air. Replace the sealing plug and cap, ensuring that they are clean, and test the crankshaft with oil under pressure as described in A.P. 1464, Vol. I, Part 4, Sect. 4, Chap. 2, para. 27. The shaft must withstand a pressure of 100 lb. per sq. in. Should the crankpin plug or cap leak, it must be refitted, but, should a leakage occur at the plug in the front end of the shaft, the plug must be withdrawn by means of the extractor shown in fig. 54, and a new one fitted as follows:—

- (i) Remove the small grub screw securing the plug.
- (ii) Screw the loose nut on the draw spindle S.R.6192 up to the nut riveted to the end of the spindle.

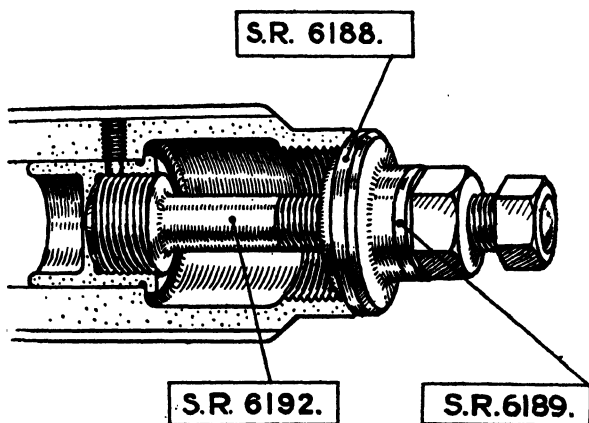


FIG. 54. Extractor for crankshaft front plug.

- (iii) Insert the plug S.R.6188 into the end of the crankshaft and screw the draw spindle into the sealing plug.
- (iv) Hold the nut riveted to the end of the draw spindle, screw the loose nut home and thus withdraw the sealing plug from the crankshaft.
- (v) Tallow the outside of the new plug and drive it home into the bore of the crankshaft. Using a No. 26 Morse drill, drill a hole in the sealing plug in line with the hole for the grub screw in the shaft. Take care not to damage the threads in the hole during the drilling operation.
- (vi) Replace the grub screw, fitting a new one if necessary, and file the end of it flush with the blank serration in the crankshaft.

After fitting a new plug the crankshaft must be re-tested under pressure.

191. Fit the rollers and outer races to the main bearings and check the side clearance between the rollers and races and the clearance on diameter between the rollers and outer races. Test the wear on the cam drum bearings ; general information on the inspection of ball and roller bearings is given in A.P. 1464, Vol. 1. Bearings should not be withdrawn from the shaft except for purposes of renewal, since their removal is apt to score the shaft. The following methods should be adopted when bearings have to be removed.

Removing the inner race of the rear main bearing

192. The extractor shown in fig. 55 should be used as follows to withdraw the inner race of the rear main bearing :—

- (i) Screw a nut to the shorter threaded end of each of the four draw bolts S.R.2127, screwing it up as far as it will go, and then pass the same ends of the bolts through their sockets in the ring plate S.R.2125.
- (ii) Engage the halves of the draw plate S.R.2128 behind the race, and secure them in this position with the assembly built up in operation (i) by screwing nuts on to the ends of the bolts until the ring plate is drawn up against the face of the draw plate.
- (iii) Insert the plug S.R.2126 or S.R.3048 in the end of the crankshaft.
- (iv) Lower the yoke plate S.R. 2136 over the outer ends of the four draw bolts and secure it square with the end of the crankshaft by nuts screwed to the ends of the bolts. Screw the extractor bolt S.R.2123 home into the yoke plate and thus withdraw the race from its mounting.

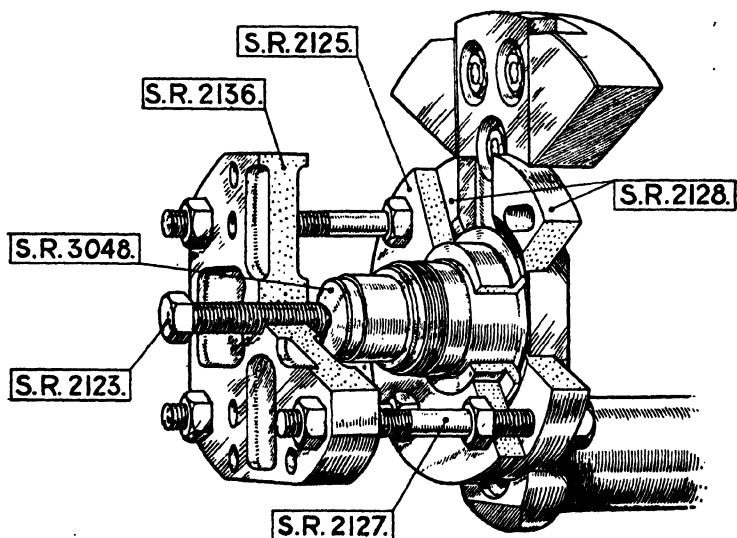


FIG. 55. Extractor for inner race of rear main bearing.

Removing the cam drum bearings

193. Both bearings are removed simultaneously with an extractor which is shown assembled in fig. 56 and is used as follows :—

- (i) Mount the two half cups S.R.5907 over the draw bolts S.R.2132 so that the shoes fitted to those bolts embrace the sides of the cups.

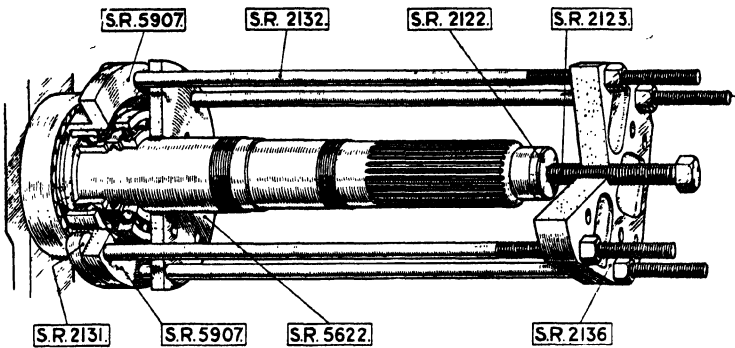


FIG. 56. Extractor for cam drum bearings.

- (ii) Engage the lips of the halves behind the outer race of the universal bearing and locate them in this position by passing the ring plate S.R. 5622 over the ends of the draw bolts until it abuts against the smaller of the two bearings.
- (iii) Place the plug S.R.2122 into the end of the crankshaft.
- (iv) Repeat operation (iv) of para 192.

Removing the inner race of the front main bearing

194. The extractor assembly shown in fig. 57 is used as follows for the removal of the inner race of the front main bearing :—

- (i) Fit nuts to the shorter threaded ends of the draw bolts S.R.2121, screwing them home as far as possible, and pass the ring plate S.R.2119 over the same ends of the bolts so that it abuts against the nuts.

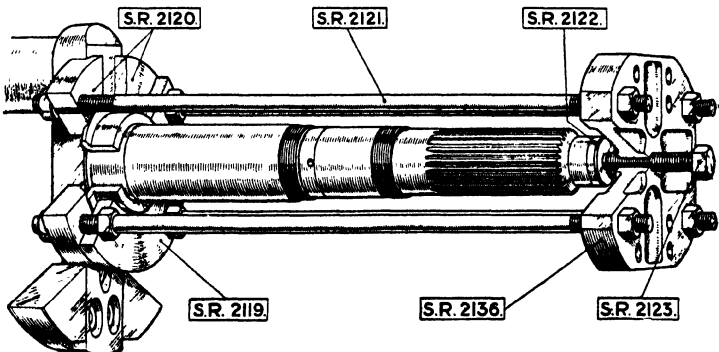


FIG. 57. Extractor for inner race of front main bearing.

- (ii) Engage the two halves of the draw plate S.R.2120 behind the lip of the race and locate them in this position by means of the assembly built up in operation (i). Secure the halves of the draw plate by nuts screwed to the ends of the draw bolts after the latter have been passed through their sockets in the draw plate.
- (iii) Place the plug S.R.2122 in the end of the crankshaft.
- (iv) Repeat operation (iv) of para. 192.

Fitting bearings to the crankshaft

195. Owing to the tight fit of the bearings on the crankshaft, it is necessary to heat them in oil to a temperature of 150°F. before fitting them to the shaft. When raised to this temperature the expansion of the bearings is sufficient to enable them to be worked on to their mountings without undue force. They should be driven home finally by means of a tubular drift. The tubular drift S.R.6185 is to be used when driving home the inner race of the front main bearing and the cam drum bearings; the order of assembly of these bearings is as follows :—

- (i) Inner race of main bearing, flanged end to the rear.
- (ii) Shroud washer.
- (iii) Universal bearing.
- (iv) Distance piece.
- (v) Journal ball bearing.

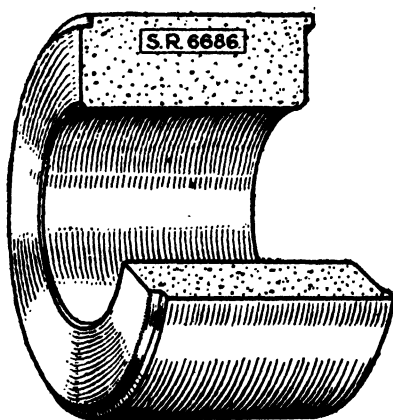


FIG. 58. Tubular drift for cam drum.

196. When fitting the cam drum to its bearings, during assembly of the engine, the drift S.R.6686 (*see* fig. 58) should be threaded over the crankshaft so that the spigot around one

end of it locates the front end of the tubular portion of the cam bearer. Hammer-blows should not be applied direct to the cam drum drift ; the latter should be driven along the shaft by means of the tubular drift S.R.6185. Another tubular drift S.R.6182 is supplied for driving the front steady bearing home.

Examination and reconditioning of front cover

197. Before examining the front cover, the components in the thrust housing must be removed. The two thrust rings, the thrust bearing carrier, the front outside distance piece and the roller bearing may be tapped out by means of a drift applied through the rear end of the housing, after which the rear outside distance piece may be removed in the same way. The steel liner for the housing is shrunk in and is not therefore removable. The following examination and adjustments may then be effected :—

- (i) Examine the housings in which the oil-retaining extensions of the thrust bearing carrier and crankshaft rear lock nut rotate for evidence of eccentric wear or scoring. Should such defects be apparent, the crankshaft rear lock nut must be screwed on to the crankshaft and the latter set up in the front and rear main bearings in the engine body and fan induction casing, after which the front cover must be fitted. Check the radial clearance between the oil retaining shank of the lock nut and the walls of its housing, using feeler gauges. Should the clearance be less than the permissible minimum at any point, the walls of the housing may be reduced at that point by scraping until the requisite clearance is obtained. Should the clearance at any point be greater than the permissible maximum, a new front cover must be fitted. Having checked the clearance around the crankshaft rear lock nut, fit the thrust bearing carrier in place on the crankshaft and check and adjust the clearance between it and the housing in the same manner. Should it be necessary to fit a new front cover, it must be set up as described and the radial clearance between the housing and the oil retaining portions of the crankshaft rear lock nut and the thrust bearing carrier checked and adjusted if necessary.
- (ii) Examine the bore of the thrust housing cover plate for signs of eccentric wear and for picking up on the crankshaft front lock nut, and check its clearance on diameter with the oil-retaining portion of the nut. If wear has occurred, a new thrust housing cover plate and nut must be fitted.

- (iii) Examine the surfaces of the thrust bearing carrier and outside distance pieces on which the thrust rings bear. Should these be grooved due to spinning of the thrust rings, the faulty components must be rejected.
- (iv) Examine the thrust rings and bearings for pits, cracks and evidence of overheating.
- (v) Place the two thrust rings and their ring of caged balls between the two outside distance pieces and check the clearance between the front thrust ring and the internal lip of the front distance piece. If the clearance is beyond that stipulated, the faulty components must be rejected.
- (vi) Place the two thrust rings and their ring of caged balls in position on the thrust bearing carrier and check the clearance between the front thrust ring and a straightedge placed across the front end of the carrier. Reject the faulty components if the clearance is beyond the permissible limit.
- (vii) Examine the races and rollers of the front roller bearing for cracks, pits and overheating. Assemble the rollers between the two races and check the wear on the bearing.
- (viii) When the front cover, thrust housing cover plate, or any component of the thrust bearing assembly is renewed, new adjusting washers must also be fitted. It is impossible to select the washers that will be employed in the final assembly of the engine at this stage, since these can only be selected during the operation of centring the crankshaft in the crankcase. Substitute washers must, however, be fitted at this stage to enable measurements to be obtained when the operation of centring the crankshaft is effected. The total thickness of the temporary washers must be such that, when the various components of the thrust housing have been assembled in the front cover and the thrust bearing cover plate is held in position by hand, a clearance of 0.003 in. \pm 0.001 in. exists between the flange of the cover plate and the facing on the front cover. It is essential that this clearance is obtained, since the cover plate fulfils the triple purpose of locating the components in the thrust housing, preventing the outer race of the airscrew roller bearing from creeping in the steel liner, and rendering the thrust housing oil-tight. On tightening the nuts retaining the cover plate to the front cover the springing of the cover

plate is sufficient to prevent creeping of the outer race of the roller bearing. The adjusting washers are supplied in twenty-one thicknesses, increasing by 0.002 in. from 0.030 in. to 0.070 in. ; only one washer of the required thickness must be employed at each end of the assembly, as shown in fig. 10.

198. Suitable adjusting washers having been selected, the thrust housing may be assembled as follows :—

- (i) Place the original or substitute adjusting washer in the back of the thrust housing.
- (ii) Tap one of the outside distance pieces into the housing.
- (iii) Lower the thrust bearing carrier, oil retaining end first, into the housing.
- (iv) Lower the thrust ring with the smaller diameter aperture into the thrust housing and follow it with the ring of caged balls and the second thrust ring. Tap the second outside distance piece and outer race of the roller bearing into the housing.
- (v) Pack the rollers, of which there are 22, around the inner race of the roller bearing and enter it, spigoted end first, into the thrust housing.
- (vi) Place the original or substitute adjusting washer in the mouth of the housing and fit the cover plate, tightening its retaining nuts evenly.

Examination and reconditioning of engine body

199. Before examining the engine body, the tappet guides must be withdrawn. Remove the circlips from around the tappet guide bolts and press the latter inwards until it is possible to turn them through 180°. Before driving out the guides with a soft drift, ensure that the halved heads of the bolts are clear of the sockets in the engine body, and that the tappets are withdrawn outwards as far as possible in the guides.

200. The engine body should be examined for cracks, all suspected parts being treated as described in A.P. 1464, Vol. I, Part 4, Sect. 4, Chap. 2, para. 28. The positions and extent of permissible cracks are shown in A.P. 1287/B.6.

201. Examine the seatings for the cylinder barrel locking rings. If the seating show signs of shouldering they must be refaced with the tool S.T.10238, illustrated in fig. 59. Before commencing to reface the seatings the cylinder adaptors must be removed and the depths of the seatings checked with a gauge and straightedge similar to those shown in fig. 60.

Should no clearance exist between the straightedge and the gauge when they are applied as shown, no further refacing is permissible and the engine body must be rejected. When refacing a seating, the tool must be used with care to avoid producing chatter marks. Only the minimum amount of metal must be removed, the lowest spot on the original facing being left as an evidence mark. After refacing, the depth of the socket must be checked again.

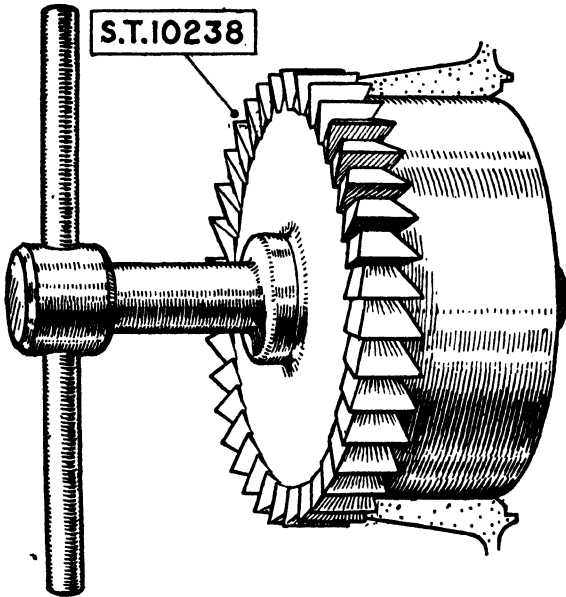
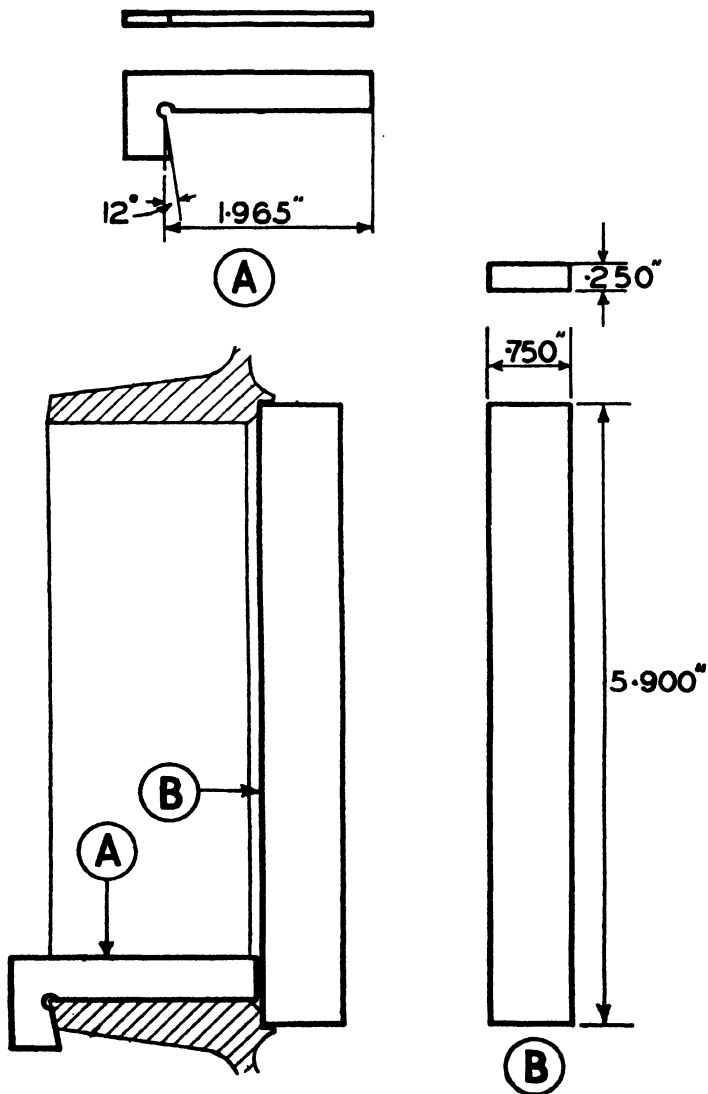


FIG. 59. Cutter for refacing cylinder sockets in engine body.

202. The outer race of the front main bearing must be examined and checked for wear. If necessary the race may be removed by first extracting the ring sprung into the mouth of the housing and then tapping the race out, taking care to keep it square in its housing.

To face p. 114.



**FIG. 60. RIG FOR TESTING
DEPTH OF CYLINDER SOCKET.**

CHAPTER VIII

OVERHAUL OF THE CAM GEAR

Tools

203. The following tools are available :—

Stores Ref. Section 36U.	Part No.	Description.	Classi- fica- tion.	Illus- trated in fig.
6882	H.A.D.178/1	Gauge for tappet guide bore.	J	—
6883	H.A.D.178/2	Gauge for bore for pin in tappet and roller.	J	—
6900	H.A.D.179/5	Gauge for cup in tappet ..	J	61
4971	S.R.5624	Tube spanner for ring nut securing inner race of ball bearing on compound gear spindle.	W.1	—
4969	S.R.5623	Tube spanner for ring nut securing outer race of ball bearing in timing gear bracket.	W.1	—
2307	H.A.D.166	Rig for testing backlash in timing gear.	J	63

Examination of tappets and guides

204. Examine the bores of the tappet guides and the shanks of the tappets for scores and signs of seizure, and check them for size and ovality, using the plug gauge H.A.D. 178/1 in the bores of the guides. Check the working clearance between each tappet and its guide. Should the guides be at all scored, or the clearances be greater than the maximum permissible, the guides, and if necessary the tappets, must be rejected. Failure in the fit between the tappets and guides results in serious oil leakage. Examine the bores of the guides for burrs at the inner ends of the recesses in which the rollers are received. Burrs may be caused by the rollers being driven up against the sharp edges of the bases of the slots in which they work when the guides are being driven out of their sockets ; this can occur only through the tappets not being withdrawn outwards through the guides before the latter are driven clear of the engine body. Remove any burrs that may exist by means of a scraper. Examine the tappet rollers and pins and check the rollers for width and diameter of the bores for the pins ; the gauge H.A.D. 178/2 is to be used to check the latter. Check the pins for length and diameter. Check the clearance between the roller and the gap in the tappet. By means of the depth gauge

H.A.D. 179/5, shown in fig. 61, ensure that the depth of the cup in each tappet for the ball end of the push rod does not exceed the permissible worn dimension. The gauge is designed for insertion into the cup, and is of such dimensions that it will only go right home if the cup is worn to the limit.

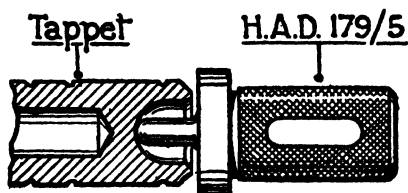


FIG. 61. Gauge for checking depth of cups in tappets.

205. After assembly of the tappets in their guides, coat the exterior of the latter with tallow and ensure that the heads of the retaining bolts are turned so that they clear the sides of the sockets. Drive the guides into their sockets so that the cylinder numbers stamped on the guides and engine body are adjacent. Tap each guide round in its socket so that a square held up to the front face of the engine body is tangential to both tappets. Turn each retaining bolt through 180° and draw it outwards into the engaged position, securing it by means of a circlip. Fit suitable temporary distance pieces and screw on and tighten the nuts of the retaining bolts. Check the tappets for freedom in their guides. It may be found that some of the tappets, which are normally a light push fit, have become partially or completely seized due to distortion of the guides caused by slight malalignment of their inner and outer sockets in the engine body. After the guides have been fitted therefore, the fit of all tappets should be tested, and those which require more than moderate thumb pressure to move them must be removed and their guides eased slightly by means of a scraper. Care must be taken not to enlarge the bores of the guides beyond the maximum worn dimension, nor to increase the clearances beyond the maximum permissible. No attempt must be made to produce an easy slide fit; the tappets must be left somewhat tight in their guides. This tightness will disappear after a few hours running, when it should be just possible to draw a tappet outwards by engaging the finger-nails at the back of the circlip. It is not advisable to remove the nuts of the tappet guide retaining bolts and the temporary distance pieces at this stage owing to the danger of accidentally turning the tappet guides in their sockets.

Marking the tappet guides and engine body for assembly

206. In order to enable the tappet guides to be assembled in the engine body without the use of a square, the guides and engine body may be marked as follows :—

207. After having fitted the tappets to the guides, proceed to mark each guide, using the rig shown in fig. 62. Place the base (A) in a vice and after having withdrawn the slide (B) so as to clear the socket, tap the guide into the base and drift it round until the blade of a square placed as shown in the illustration is tangential to both tappets. Advance the slide until it is in the position shown in the sketch, and, using it as a guide, scribe a line on the top and over the edge of the guide. All guides so marked may be set up in their sockets in the engine body without the use of a square.

208. Before commencing to fit the tappet guides to the engine body, proceed as follows to mark the engine body in the vicinity of the sockets. Tap the plug (D) of fig. 62 into one of the tappet guide sockets so that one of the projecting ends of the flange overhangs the end of the engine body. Using a drift applied to the peg (E), tap the plug round until the edge of the flange is tangential to a square held up to the face of the engine body. Using the edge of the flange as a guide, scribe a line on the engine body. Each tappet guide socket is to be marked as described above, and when so marked will enable any tappet guide marked as described in para. 207 to be assembled without the use of a square.

Examination of push rods

209. Test all push rods for straightness by rolling them on a flat surface and examine their ends for wear. Reject any that are bent or badly worn.

Examination of cam drum

210. As the cam ring, cam bearer and annulus constitute a unit, failure of any one of its components necessitates rejection of the unit. The most likely reasons for rejection are distortion of the cam bearer and wear of the annulus. If wear has occurred on the cams, the flat surface may be restored by careful stoning. In order to test the lateral truth of the cam ring, the cam drum unit should be mounted on a surface table upon a bush or plug which is an easy fit in the bore of the housing for the rear cam drum bearing. The bush, which should be about $1\frac{1}{2}$ in. long, must have its ends square and parallel with one another. A number of dial indicator readings, the indicator being mounted upon a suitable stand or scribing block, should now be taken around the front face of the cam ring. The difference between the

greatest and least readings must not exceed the stipulated figure. The wear of the annulus is checked when measuring the backlash of the timing gears.

Dismantling, examination and assembly of timing bracket

211. The sequence of operations for dismantling the timing bracket is as follows :—

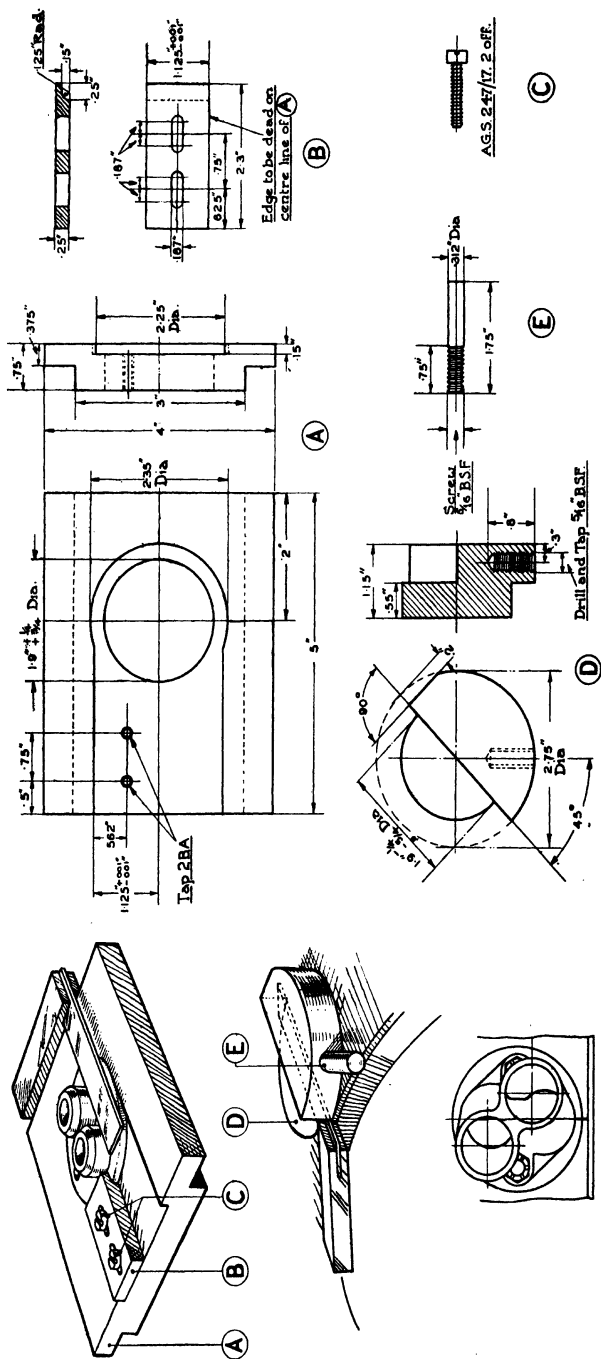
- (i) Remove the plates securing the outer races of the roller bearings in which the rear ends of the gear wheel spindles are mounted. Check the clearance between the rollers and outer races.
- (ii) Remove the split pins and nuts from the front ends of the gear wheel spindles, using the tube spanner S.R.5624 to slacken the nuts.
- (iii) Tap the spindles clear of the bracket through their rear bearing housings and remove the gear wheels and distance pieces. It is important that the components of the two compound gear wheels are not interchanged, otherwise it may be found during assembly that the split pin holes in the front ends of the spindles and in the ring nuts do not coincide.

212. Examine the gear wheels and pinions as described in A.P. 1464, Vol. I, Part 4, Sect. 4, Chap. 2, para. 31. Test the wear of each ball bearing and renew it if necessary. The old bearing may be removed by withdrawing the split pin and unscrewing the ring nut in the mouth of its housing by means of the spanner S.R.5623, after which the bearing may be tapped out by means of a drift. After a new bearing has been fitted, the ring nut must be screwed home as tight as possible and the alignment of the split pin hole in the ring nut with that of the hole in the mouth of the housing must be checked. In the same circumstances, and also when fitting a new roller bearing, the alignment of the hole in the gear wheel spindle with the hole in the ring nut must also be checked.

213. The sequence of assembly of the timing bracket is as follows :—

- (i) Tap the outer races of the roller bearings into their housings and fit the keeper plates, securing each nut to its screw with a split pin.
- (ii) Tap the ball bearings into their housings, screw home the retaining nuts by means of the spanner S.R. 5623, and lock them with split pins, the heads of which must face outwards.

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PLAN VIEW OF GUIDE & PUSH ROD COVER BRACKET
SHOWING LINES SCRIBED ON GUIDE & ENGINE BODY

FIG. 62 . RIGS FOR PLACING ASSEMBLING MARKS ON TAPPET GUIDES & ENGINE BODY.

- (iii) Tap the inner races of the roller bearings on to their spindles and insert the keys for the gear wheels into their keyways.
- (iv) Insert the gear wheels into their sockets in the timing bracket and thread the spindles through them from the rear end of the bracket. After the gear wheels, thread on the distance pieces so that their chamfered ends will abut against the ball bearings. Position the rollers around the inner races of the roller bearings, and, as soon as the screwed ends of the spindles project beyond the inner races of the ball bearings, screw on the nuts and thus draw the spindles fully home. When the nuts have been tightened, lock them to the spindles with split pins.

Testing backlash in timing gears

214. Fig. 63 illustrates a rig, H.A.D.166, by which the backlash between the following components may be measured independently of each other :—

- (i) Cam drum annulus and the pinion end of each compound gear wheel.
- (ii) Crankshaft driving sleeve and the larger gear of each compound gear wheel.

215. The measurements are made during the erection of the engine immediately after the valve timing has been adjusted and are effected as indicated in the following paragraph :—

- (i) Withdraw the crankshaft driving sleeve, remove the split pins from the front ends of the timing wheels and lock the cam drum unit lightly to the engine body with a wooden wedge inserted between the cam ring and the lip which supports the inner ends of the tappet guides.
- (ii) Remove one of the nuts which retain the timing bracket to the engine body, replacing it with the pillar of the rig.
- (iii) Fit a dial indicator in the clip of the bracket, mount the bracket upon the end of the pillar and after slackening the clamp nut of the pointer, drop the shank of the latter into the bore of one of the timing wheel spindles.
- (iv) Adjust the pointer, indicator and bracket, so that the inner knife edge of the pointer bears normally upon the ball end of the indicator and causes a deflection of the needle. Lock the pointer indicator and bracket in this position.

- (v) Rock the timing wheel through the range of backlash and note the readings of the indicator.
- (vi) Slacken the clamping nut of the pointer so as to free the latter in the timing wheel, remove the wedge from the cam drum, turn the latter through $\frac{1}{4}$ th of a revolution and then lock it in this second position.
- (vii) Repeat operations (iv) and (v).
- (viii) Repeat operations (vi) and (vii) until the backlash of the timing wheel for six different positions of the annulus have been measured. Calculate the mean value of the backlash.
- (ix) Transfer the pointer to the second timing wheel and swing the indicator and bracket across the engine so as to be operated from the pointer in its new position.
- (x) Repeat operations (iv) to (viii).
- (xi) It will probably be found that the mean values of the backlash between each wheel and the annulus will differ. If this is so, the bracket must be tapped over on its studs until it is found by repeating operations (v) to (x) that the mean backlash of the two wheels is the same. Having balanced the mean backlash values, note the maximum and minimum values for each wheel.
- (xii) Remove the wedge which locks the cam drum unit and turn the cam ring in the direction of normal rotation until No. 1 inlet valve is about to be lifted.
- (xiii) Turn the crankshaft in the direction of normal rotation till it is in the correct position for the opening of No. 1 inlet valve.
- (xiv) Replace the crankshaft driving sleeve. The sleeve should be driven home gently and the two timing wheels rocked through the range of backlash with the annulus until they have been engaged by the sleeve. This will prevent the sleeve from "hanging up" on the timing wheels and damage being done to the latter by further attempts to drive the sleeve home.
- (xv) Remove the push rods from No. 1 cylinder and withdraw all tappets as far as possible through the guides so as to leave the cam ring clear of all obstructions.
- (xvi) Adjust the indicator, bracket and pointer so that the outer knife edge of the pointer bears normally upon the ball end of the indicator and causes a deflection of the needle. Lock the pointer, indicator and bracket in this position.

To face p. 120.

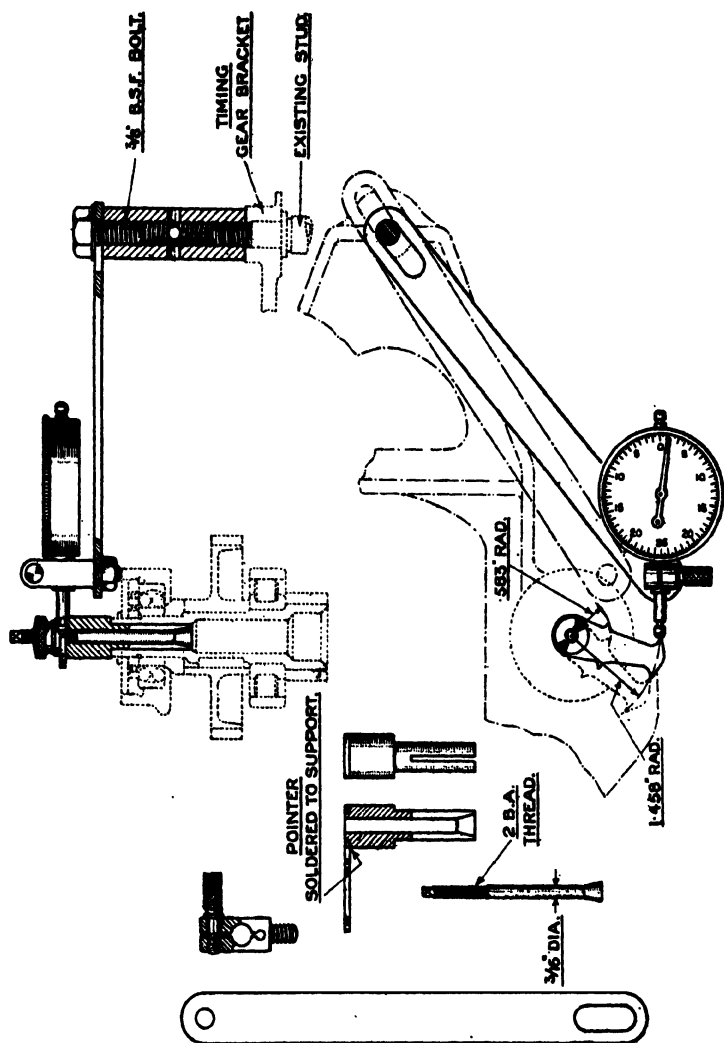


FIG. 63. RIG FOR TESTING BACKLASH IN TIMING GEARS.

- (xvii) Measure the backlash between the timing wheel and the driving sleeve for this and five other positions of the crankshaft as previously instructed, and calculate the mean value.
- (xviii) Transfer the pointer indicator and bracket to the second timing wheel, obtain values for the backlash between the wheel and the driving sleeve for six different positions of the crankshaft, and calculate the mean value.
- (xix) If the mean values of the backlash between the two timing wheels and the driving sleeve should differ, the timing bracket must be tapped over on its studs until it is found on repeating operations (xvii) and (xviii) that half the difference has been corrected. This will distribute the difference equally between annulus and driving sleeve ; if the whole difference had been equalised between the two wheels and the driving sleeve it would have been transferred wholly to the two wheels and the annulus. With the timing bracket thus set, the maximum and minimum values of the backlash between the timing wheels and driving sleeve should not lie outside the range laid down, nor should the backlash between the timing wheels and the annulus. The maximum and minimum values of the backlash between the timing wheels and annulus with the timing bracket in the new position may be arrived at by adding or subtracting the amount by which the backlash between the timing wheels and driving sleeve has just been altered, to the maximum and minimum values noted in operation (xi), adding the amount to the timing wheel which has had its backlash with the driving sleeve decreased and vice versa.
- (xx) Remove the test rig from the engine and replace the nut on the timing bracket and the split pins in the timing wheel spindles.

CHAPTER IX

OVERHAUL OF THE REAR COVER, INDUCTION CASING,
FAN, ENGINE SPEED INDICATOR AND MAGNETO DRIVES
AND HAND STARTER GEAR

Tools

216. The following tools are available :—

Stores Ref. Section 36U.	Part No.	Description.	Classi- fica- tion.	Illus- trated in Fig.
4999	J.21169	Mounting sleeve for re- grinding fan gland.	W.2	64
5014	S.R.5809	EXTRACTOR FOR OUTER RACE OF REAR MAIN BEAR- ING, <i>consisting of</i> :—		
	S.R.5814	Draw bolt (6 off) ..	J	65
	S.R.5811	Shoe (3 off) ..		
	S.R.5812	Ring plate (1 off) ..		
	S.R.5810	Extractor plate (1 off) ..		
	S.R.6989	Draw plate (1 off) ..		
	S.R.6990	Extractor bolt (1 off) ..		
	S.R.5813	Pins for extractor plate (4 off).		
	A.1.116.E	Nut for draw bolt (6 off) ..		
4902	S.R.3097	Extractor for bevel gears on magnetos and engine speed indicator drive unit.	F	69
2311	H.A.D.170	Rig for checking backlash of magneto drive shaft.	J	66
2309	H.A.D.168	Rig for checking backlash of magneto bevel wheels.	J	67

Examination of rear cover

217. Examine the rear cover for cracks and all studs for looseness and condition of threads. Replace any loose studs by new ones passed on the high limit. Examine the joint faces for distortion or damage. Examine the felt lining of the magneto drive shaft oil retaining bush and if necessary renew it. Clean the interior of the oil jacket thoroughly.

Examination of induction casing and fan gland

218. Examine the mating face for the fan gland on the back of the rear main bearing housing ; if it is scored the face must be restored by careful scraping. Examine the face of the fan gland and if necessary skim it up in a lathe. The mating of the

two faces should be checked as shown in fig. 64, the mounting sleeve J.21169 being fitted to the rear end of the crankshaft in place of the fan. A number of radial indelible pencil marks must be made upon the gland face. The gland must then be mounted upon the mounting sleeve and rotated in contact with the face on the bearing housing. If the gland is true, all pencil marks will be obliterated. Repeat the operation, marking the face on the housing instead of that on the gland; as before all marks must be obliterated on rotation of the gland. This procedure must be adopted when either component is renewed. If the lack of truth in the gland or the housing is small, it may be corrected by grinding the two parts together, using fine valve grinding paste as an abrasive. All abrasive must be removed after grinding.

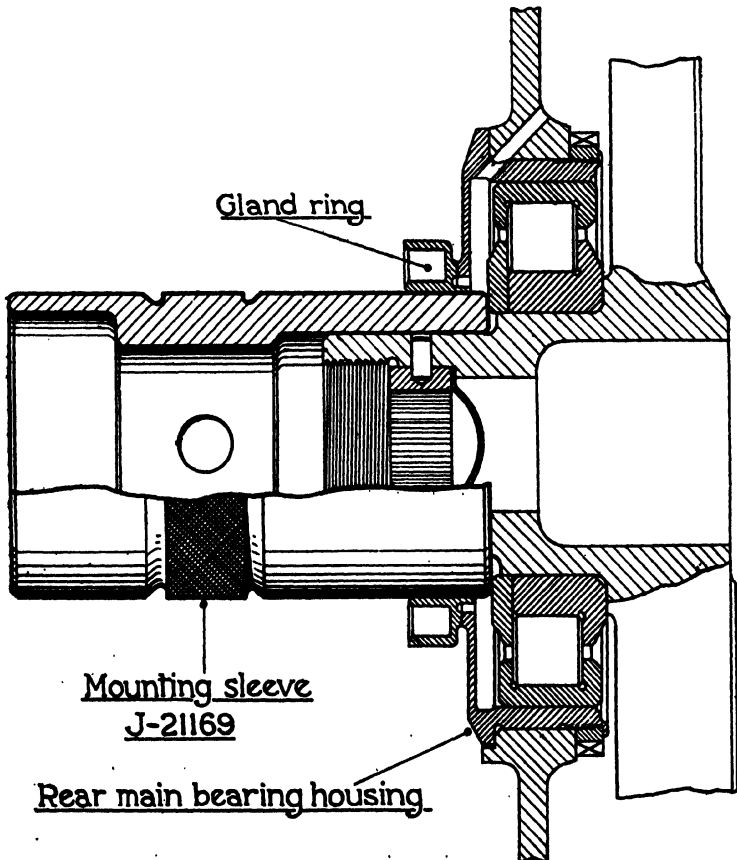


FIG. 64. Mounting sleeve for regrinding fan gland.

219. Examine the gland packings in the sockets for the induction pipes and if necessary renew them. The packing is interposed between the two duralumin rings, and care must be taken to ensure that the chamfered faces of the rings are in contact with the packing.

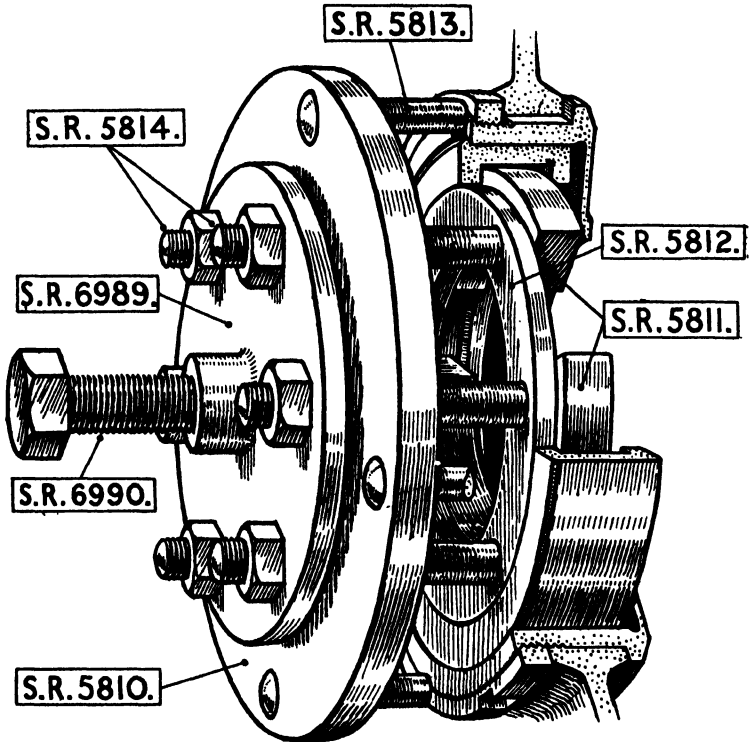


FIG. 65. Extractor for outer race of rear main bearing.

220. If it is necessary to remove the outer race of the rear main bearing, the extractor shown in fig. 65 should be used as follows :—

- (i) Engage the shoes S.R.5811, with the six draw bolts S.R.5814 fitted, behind the front lip of the race and locate them in this position by means of the ring plate S.R.5812.
- (ii) Fit the extractor plate S.R.5810 over the draw bolts so that its feet bear around the nut of the bearing housing.
- (iii) Secure the draw plate S.R.6989 to the draw bolts and screw home the extractor bolt S.R.6990.

Examination of fan

221. Examine the fan for cracks and check it for errors in lateral truth at the tips of the blades. The check may be made by means of a dial test indicator mounted on a scribing block and applied to the tips of the blades. The fan boss should be mounted on a packing block having parallel and square ends and placed upon a surface plate.

222. Examine the fan for fit on the crankshaft and driving key. The fit must be such that the fan may be pushed home with a steady hand pressure without the key in position ; the fit of the key in its keyway should also be close. Fans unserviceable in these respects are modified by the makers by boring out the hub and screwing in a steel liner.

Dismantling, examining and assembling the engine speed indicator drive unit

223. The engine speed indicator drive unit should be dismantled as follows :—

- (i) Unscrew the two screws which retain the bearing of the driven shaft and withdraw the bearing and shaft.
- (ii) Unscrew the nuts which retain the steel bearing housing to the aluminium casing after bending back the tab washers.
- (iii) Grip the bearing housing lightly in a lead-jawed vice and tap the upper portion of the casing clear of it.
- (iv) Remove the split-pin and nut securing the bevel wheel to the lower end of the spindle and withdraw the bevel wheel by means of the extractor S.R.3097 (see fig. 69). Remove the key.
- (v) Remove the split pin, nut and washer from the upper end of the spindle and tap the latter through the bores of the inner race of the upper bearing and worm. Remove the key.
- (vi) Remove the ring sprung into the mouth of the bearing housing and support the flange of the housing across the jaws of a vice. Tap the spindle through the housing and thus withdraw the universal bearing.
- (vii) Tap the spindle clear of the inner race of the bearing.

224. Examine the bevel wheel, worm, worm wheel and driven shaft bearing for wear. Check the ball races for wear and examine the casing for cracks. Assemble the unit as follows :—

- (i) Tap the universal bearing on to its mounting on the driving spindle, enter the latter into the lower end of the steel bearing housing, tap the outer race of the bearing into the housing and fit the spring ring into its groove in the mouth of the housing.

- (ii) Fit the key for the bevel wheel into its keyway in the spindle, mount the bevel wheel on its taper, fit the plain washer and nut and split-pin the latter.
- (iii) Fit the key for the worm into its keyway in the spindle and tap the worm on to its mounting. Tap the upper ball bearing on to its mounting, fit the plain washer, screw on and tighten the nut and split-pin it.
- (iv) Tap the casing over the bearing housing and secure the two components together with nuts and tab washers fitted to the four retaining studs.
- (v) Oil the shank of the driving spindle and the bore of its bearing and enter the spindle into its bearing. Insert the bearing into its socket in the casing, at the same time rotating the bevel wheel so as to draw the worm wheel into mesh with the worm. Secure the flange of the bearing to the casing with the two setscrews.

Examination of magneto drive shaft

225. The magneto drive shaft may be dismantled by unscrewing the ring nut at its rear end and then tapping the shaft through the magneto driving bevel and hand starter claw. Care must be taken not to lose any of the shims fitted on either side of the inner race of the ball bearing. The ball bearing may be tapped from its housing after the ring sprung into the mouth of the housing has been removed.

226. The splines at both ends of the shaft, the ball bearing, the teeth of the bevel wheel and the hand starter claw should all be examined for cracks and wear.

227. To assemble the shaft, tap the bevel wheel on to the shaft and the ball bearing into its housing ; fit the spring ring in the mouth of the housing. Pass the pack of shims originally fitted between the bevel wheel and bearing over the end of the shaft and tap the bearing and housing home on to the sleeved extension of the bevel wheel. Pass the second pack of shims over the end of the shaft and fit the starter claw, securing it with the ring nut, which is locked by means of a tab-washer. Do not bend up the tab of the washer until the backlash of the magneto bevel wheels and the setting of the hand starter gear have been checked.

Checking backlash between the magneto drive shaft and the crankshaft

228. A rig, H.A.D.168, by which the backlash between the magneto drive shaft and the crankshaft may be tested is shown in fig. 66. When using the rig, the hand starter is removed from the back of the rear cover, the clip fitted around the starter claw, a dial indicator fitted in the clip on the indicator bracket and the bracket attached to one of the studs on

To face p.126.

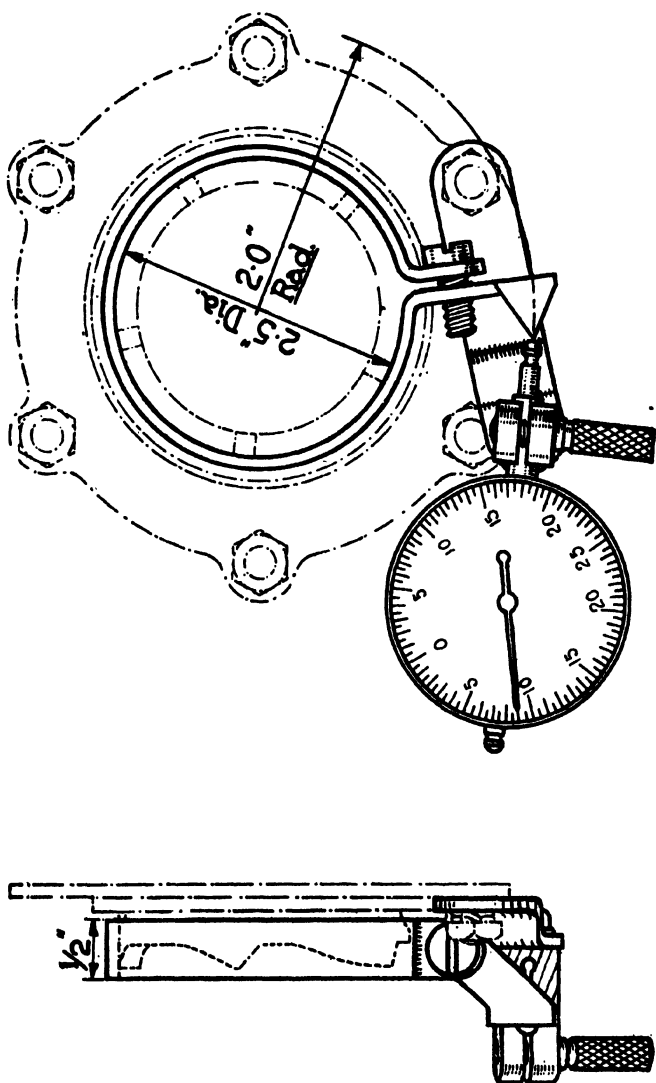


FIG. 66. RIG FOR TESTING BACKLASH OF MAGNETO DRIVE SHAFT

the flange of the rear cover. Clip, indicator, and bracket are adjusted so that the knife edge on the clip bears normally upon the ball end of the indicator and causes a deflection of the indicator needle. The three components are locked in this position, the magneto drive shaft rocked through the range of backlash and notes made of the readings of the indicator. The indicator deflection, when divided by the radius in inches swept by the knife edge of the clip, should not exceed the figure laid down for backlash.

Checking backlash between the magneto bevel wheels and the magneto drive shaft bevel wheel

229. Fig. 67 shows a rig, H.A.D.170, which, in conjunction with the test rig for the magneto drive shaft, enables the backlash between any one magneto bevel wheel and the bevel wheel of the magneto drive shaft to be measured. To use the rig, the contract breaker cover and cam retaining screw of the magneto concerned must be removed and the pointer attached to the cam by a screw of the size shown in the drawing. A dial indicator is mounted in the clip on the indicator bracket and the bracket is secured to the standard on the magneto which normally carries the clip or plate by which the contact breaker cover is secured. The crankshaft is next turned and the setting of the indicator and bracket adjusted so that the knife edge of the pointer bears normally upon the ball end of the indicator and causes a deflection of the indicator needle. The crankshaft is allowed to remain in this position and the backlash between the magneto drive shaft and crankshaft is taken up by tying the pointer or clip of the magneto drive shaft test rig to the indicator bracket of that rig. The backlash of the magneto bevel wheel can then be measured by rocking the magneto spindle through the backlash range and noting the deflection of the indicator needle. If the backlash of both magneto bevel wheels is too great or too small, a correct depth of mesh can be obtained by increasing or decreasing the thickness of the pack of shims fitted between the shoulder at the back of the drive shaft bevel wheel and the inner race of the bearing behind it. If one magneto bevel wheel only is incorrectly meshed, it may be adjusted by varying the thickness of the shims fitted between the magneto and the side of the rear cover. The addition of shims increases the backlash.

Dismantling, examining and assembling the hand starter gear

230. The hand starter gear should be dismantled as follows :

- (i) Remove the split-pin and unscrew the nut from the upper end of the guide tube.
- (ii) Lift the spring and spring cup clear of the guide tube.

- (iii) Remove the split-pin and unscrew the nut that retains the pivot bolt.
- (iv) Remove the pivot bolt and withdraw the guide tube from the sliding head.
- (v) Remove the split-pin and unscrew the nut from the end of the rocking shaft.
- (vi) Withdraw the operating lug and sliding head from the end of the rocking shaft as a unit, and remove the key.
- (vii) Remove the split-pins and unscrew the nuts which retain the platform at the end of the rocking shaft bearing standard to the side of the casing.
- (viii) Withdraw the bearing standard, leaving the rocking shaft in the casing.
- (ix) Withdraw the rocking shaft.
- (x) Withdraw the turning claw from the front end of the casing.
- (xi) Remove the split-pins and unscrew the nuts which retain the flange of the worm shaft bearing to the casing.
- (xii) Remove the ratchet pawls and their springs.
- (xiii) Withdraw the worm shaft from the casing.
- (xiv) Unscrew the nuts that retain the two halves of the casing and split the casing.
- (xv) Lift out the worm wheel.

231. Examine the worm and worm wheel for scoring, chipping and wear of the teeth. Examine the ball and roller bearing tracks in the worm wheel carrier and the outer races of these bearings for pitting and cracks; check the clearance on diameter between the rollers and outer race. With the gear assembled, check the end float of the worm wheel carrier. Examine the serrations in the bore of the worm wheel carrier and on the turning claw for damage and wear. Examine the jaws of the turning claw for chipping and wear. Check the worm shaft bushes for wear and the shaft for end float; examine the thrust bearing for pitting, cracking and discolouration of balls and races. Examine the ratchet and pawls for chipping, wear and cracks and ensure that the springs operate the pawls correctly. Examine all pivots, crankpins, journals and bushes of the actuating mechanism for wear.

232. The sequence of operations for assembling the hand starter gear is as follows :—

- (i) Pack the eighteen balls around their outer race in the front portion of the casing of the unit. A thick grease may be employed to hold the balls in position.



RIG FOR CHECKING BACKLASH OF MAGNETO BEVEL WHEELS.

- (ii) Lower the worm wheel into the front portion of the casing so that its shank engages the bore of the ring of balls.
- (iii) Drop the ring of caged rollers over the rear end of the shank of the worm wheel and pour oil liberally over it.
- (iv) Apply liquid jointing compound to the seating around the rear face of the front portion of the casing and fit the rear portion of the casing to it. Secure the two portions of the casing together, placing a spring washer under each retaining nut.
- (v) Tap the universal bearing fitted to the operating link into its housing in the turning claw so that the end of the link projects through the shank of the claw. Secure the outer race of the bearing in position by springing the ring into its groove around the mouth of the housing.
- (vi) Insert the turning claw into the bore of the worm wheel through the front end of the casing.
- (vii) After cleaning and oiling its shank, insert the rocking shaft through the bore of its bearing housing.
- (viii) By manipulating the turning claw engage the crank-pin at the end of the rocking shaft with its socket in the end of the operating link.
- (ix) After cleaning and oiling its bore, slide the bearing standard of the rocking shaft home into its housing over the shank of the rocking shaft. Make a joint with liquid jointing compound between the flange of the standard and its seating on the casing.
- (x) Secure the flange of the bearing standard to the casing, securing each nut with a split pin. Do not as yet fit the pivot bolt.
- (xi) Place the key for the operating lug in its keyway in the rocking shaft and mount the lug in position.
- (xii) Secure the lug in position on the shaft, placing the washer over the end of the latter and then screwing home the retaining nut, which must be split-pinned in position.
- (xiii) Test the end play of the rocking shaft in its bearing. It should have a movement of 0.010 in. to 0.015 in. This may be adjusted by varying the setting of the plug screwed into the rear end of the casing co-axial with the rocking shaft. When once set the plug must be split-pinned in position.

- (xiv) Swing the sliding head about its knuckle joint until it can be engaged between the cheeks of the bracket on the flange of the bearing standard.
- (xv) Slide the guide tube home into the bore of the sliding head until the hole drilled through its lower end will register with the socket for the pivot bolt.
- (xvi) Fit the pivot bolt and split-pin its nut in position.
- (xvii) Place the spring over the guide tube, mount the spring cup in place and screw the nut home temporarily.
- (xviii) Slide the worm shaft unit home into its socket.
- (xix) Place a pawl spring in each of the sockets on the flange of the worm shaft bearing and mount a pawl over each of the retaining studs.
- (xx) Screw home the two retaining nuts and split-pin them in position.
- (xxi) Adjust the setting of the gear as described in paras. 135 and 136.

CHAPTER X

OVERHAUL OF THE OIL PUMP

Tools

233. The tools and gauges listed below are available.

Stores Ref. Section 36U.	Part No.	Description.	Classi- fica- tion.	Illus- trated in Fig.
4910	S.R.5591	Spanner for cap of filter chamber.	F	—
6892	H.A.D.178/ 11	Gauge for bore of casing for gears.	J	—
6893	H.A.D.178/ 12	Gauge for bore of driving spindle bushes in upper half casing.	J	—
6890	H.A.D.178/9	Gauge for bore of driving spindle bush in lower half casing.	J	—
6891	H.A.D.178/ 10	Gauge for bore of driven spindle bushes.	J	—
5026	S.T.10239	Reamer, $\frac{1}{8}$ -in. dia. for bushes.	J	68
5020	S.T.10240	Reamer, $\frac{1}{2}$ -in. dia. for bushes.	J	—
5022	S.T.10241	Reamer, $\frac{7}{16}$ -in. dia. for bushes (with guide bush).	J	—
5010	—	Guide bush for use with S.T. 10239 and S.T. 10240.	J	68

Dismantling, examining and reconditioning

234. The oil pump is dismantled and examined in two stages, of which the first is as follows :—

- (i) Hold the oil pump skew gear wheel in a lead-jawed vice, bend back the tab of the washer securing the nut which retains the gear to the pump spindle, and unscrew the nut. Withdraw the case from the skew gear wheel by tapping the case with a hide hammer ; do not attempt to remove the case by tapping the end of the pump spindle as this is liable to bend the spigot at the end of the spindle. Remove the key for the skew gear wheel from the pump spindle.
- (ii) Remove the bolts securing the two halves of the pump casing to each other and separate the halves.
- (iii) If the scavenge pump driven pinion has remained in the lower portion of the casing, remove it and replace it upon its spindle. Test the clearance between the teeth of the scavenge pump gears in several positions, using narrow feelers between the meshing teeth.

- (iv) Remove the scavenge pump driven pinion and spindle and withdraw the driving spindle with the scavenge and feed pump driving pinions still fitted.
- (v) Remove the scavenge pump driving pinion by gripping it in a lead-jawed vice and tapping the spindle through it. Remove the key and D-washer from the spindle.
- (vi) Replace the driving and driven spindles, with the feed pump driving and driven pinions mounted upon them, in the upper portion of the casing, and check the clearance between the teeth of the pinions in several positions and also between the pinions and the walls of the pump casing.
- (vii) Remove the driving spindle, driving pinion, driven spindle and driven pinion from the pump casing, grip the feed pump driving pinion in a lead-jawed vice and tap the pinion through it.
- (viii) Insert the driving and driven spindles, with the scavenge pump driving and driven pinions mounted temporarily upon them, in the scavenge pump casing, and check the clearance between the pinions and the walls of the pump casing. Remove the spindles and pinions and tap the driving spindle through the driving pinion.
- (ix) Remove the locking washer and cap from the mouth of the filter chamber and remove the filter.
- (x) Remove the split-pin from the relief valve adjusting plug, unscrew the latter and remove the spring and relief valve.

235. The second stage comprises examination of the components, and this is dealt with from a general viewpoint in A.P. 1464, Vol. I, Part 4, Sect. 4, Chap. 2, para. 29. Certain additional operations, or those which it is necessary to describe more fully, are effected as follows :—

- (i) When examining the oil pump casing for cracks, the bores for the pinions in both portions of the casing should be checked by means of the plug gauge H.A.D. 178/11.
- (ii) Examine all bushes and journals for wear and check their clearances. The bores of the bushes for the driving spindle in the upper portion of the casing should be checked with the gauge H.A.D. 178/12 ; both bushes must be renewed if either is faulty. The gauge H.A.D. 178/9 is provided for checking the bore of the bush for the driving spindle in the lower portion of the casing, whilst the gauge 178/10

is for a similar purpose for both driven spindle bushes. All bushes are light drive fits in their housings; the bush for the upper end of the driving spindle must be driven out from the lower end of the upper half of the casing, whilst the four remaining bushes must all be driven out into the pump chambers. Before replacement bushes are driven home, their shanks must be tallowed, and when home they must be reamed. When fitting the bush which incorporates the relief valve body into the bottom half of the pump casing, ensure that the slots in the threaded end of the bush are in the same plane as that through the axes of both spindles. Unless this is so, difficulty will be experienced when split-pinning the relief valve adjusting plug. The two driving spindle bushes are reamed

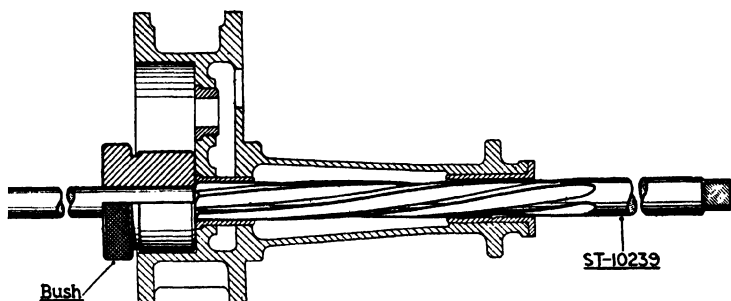


FIG. 68. Reaming bushes for driving spindle in oil pump casing.

simultaneously with the large reamer S.T. 10239, as shown in fig. 68. When in use its lower end is steadied in a bush marked "Use with S.T. 10239 and S.T. 10240," which is to be inserted in the housing for the feed pump driving pinion. The bush for the lower end of the driving spindle is reamed with the reamer S.T.10241, the reamer being steadied in the bush marked "For S.T. 10241," which is to be inserted in the housing for the scavenge pump driving pinion. Both bushes for the driven pinion spindle are reamed with the reamer S.T. 10240, the reamer being steadied in the bush marked "Use with S.T. 10239 and S.T. 10240," which is to be mounted in the housing for the driven pinion of the pump concerned.

- (iii) Examine the D-washers which separate the two pump chambers for scores and check their thickness. If one washer is faulty both must be

renewed ; the steel washer is supplied to size, but the phosphor bronze washer requires fitting. Its flat must be reduced so that both washers are an accurate fit in the mouths of the pump chambers.

- (iv) If any of the pinions are rejected, the pinion which meshes with that rejected must also be renewed.
- (v) Check, and if necessary, adjust the end clearance of the pump pinions in their housings. The total clearance of both pairs of pinions may be found by measuring, by means of a depth gauge, the clearance between each pair of pinions and the mouth of its housing, by adding these two clearances together and then subtracting from the result the thickness of the D-washers. The result thus obtained must not exceed the total thickness of the figure-of-eight shims fitted between the pinions and their casings, by more than twice the clearance quoted for one pump in A.P. 1287, Vol. II, Part 2. The shims are supplied in thicknesses of 0.004 in., 0.007 in. and 0.010 in. If possible they should be arranged so that shims of the same thickness are used in both pump chambers.
- (vi) Examine the seating for the relief valve and the facing of the valve itself for evidence of incorrect seating.

Assembling

236. The following is the sequence of operations for assembly :—

- (i) Fit the key for the feed pump driving pinion in its keyway in the driving spindle and tap the pinion on to its mounting. This pinion is the shallower of the two driving pinions and is to be fitted so that the recess in its end receives the shoulder on the spindle.
- (ii) Place the correct shim in the feed pump chamber, and, after oiling the pump spindle and its bushes, fit the spindle into the upper portion of the pump casing.
- (iii) After oiling the bore of the feed pump driven pinion, the spindle and its bush in the feed pump chamber, drop the spindle into position and fit the pinion.
- (iv) Fit the phosphor bronze D-washer over the driving spindle and the steel washer over the driven spindle. Tap the two washers into the mouth of the feed pump chamber.

- (v) Fit the key for the scavenge pump driving pinion in its keyway in the spindle and tap the driving pinion on to its mounting.
- (vi) Fit the driven pinion over the end of the spindle and place the correct adjusting shim upon the two pinions.
- (vii) After lubricating the bushes in the scavenge pump chamber, lower the bottom half casing over the upper, making a joint with liquid jointing compound between the two casings and securing them with their bolts. A plain and a spring washer is to be fitted beneath the nut fitted to each bolt.
- (viii) Fit the relief valve in its housing, insert its spring and screw the adjusting plug home temporarily.
- (ix) Blank off the delivery port of the feed pump and connect the inlet union of that pump to some form of pressure oil pump to which a gauge is attached. Pump oil into the pump and adjust the setting of the relief valve spring adjusting plug until the valve lifts at 85 lb. per sq. in. Having adjusted the valve, lock it with a split-pin.
- (x) Enter the filter into its housing, place a fibre washer around the cap and screw the latter into the mouth of the filter chamber. Fit the locking washer and its retaining ring.

CHAPTER XI

OVERHAUL OF IGNITION SYSTEM

Examination of ignition cables

237. Examine all cables for security of end fittings and for fraying of their braiding where they are supported in clips or where the sharper bends occur. Cables with frayed braiding must be renewed as there is a danger of the frayed ends of the braiding working their way through the insulation and causing a short circuit. No attempt must be made to recondition frayed braiding by soldering. Examine the cables for burning, especially at the ends in proximity to the exhaust system and cylinder heads. Any cables in which rubber is found to be exuding through the braiding due to overheating must be renewed.

Preparing new ignition cables

238. The lengths of all cables used on the engine are as follows :—

Cylinder.	To Port Magneto.	To Starboard Magneto.
1	48 in.	48½ in.
2	41½ in.	51 in.
3	47 in.	53½ in.
4	49½ in.	57½ in.
5	58½ in.	51 in.
6	54 in.	47½ in.
7	53 in.	40 in.

The lengths given above are the finished lengths between the bared ends of the cable when fitted.

239. The method of fitting the terminals at the sparking plug ends of the cable is fully described in A.P.1464, Vol. I, Part 3, Sect. 7, Chap. 3. The braiding should be stripped back for a length of 2½ in. The method of preparing the magneto distributor ends of the cables is as follows :—

- (i) Thread an appropriately numbered and coloured sleeve and the retaining nut over the end of the cable.
- (ii) Slit the braiding for a length of 1½ in., trim the stripped portion, thread on an outer and an inner sleeve and press the outer sleeve over the inner as described in A.P. 1464, Vol. I.
- (iii) Remove the insulation from the end of the cable for a distance of ¾ in. and tin the end of the cable.

- (iv) Coat the bore of an insulating thimble with thick shellac varnish and pass it over the end of the cable until it bears around the shoulder of the inner sleeve.
- (v) Pass the small metal thimble over the end of the cable which projects beyond the insulating thimble and solder it in position.
- (vi) Cut off any cable which projects beyond the end of the thimble and clean up the end of the soldered joint flush with the end of the thimble.

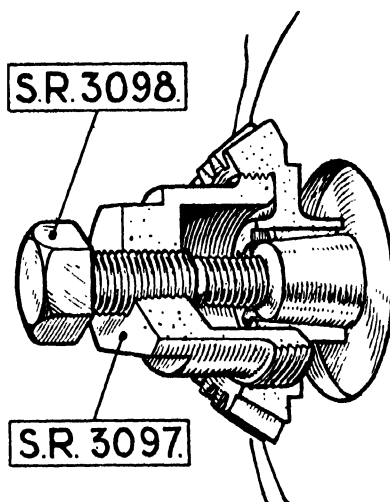


FIG. 69. Extractor for bevel wheels of magnetos and engine speed indicator drive unit.

Removal of bevel wheels from the magnetos

240. The bevel wheels may be removed from the magnetos by means of the extractor shown in fig. 69. After removal of the nut securing the bevel wheel the plug S.R.3097 should be screwed into the mouth of the wheel. On screwing the set bolt S.R.3098 into the bore of the plug the wheel will be forced from its taper.

CHAPTER XII

OVERHAUL OF THE CARBURETTOR

General

241. Overhaul of carburettors is described in A.P. 1464, Vol. I, Part 4, Sect. 5, Chap. 6, to which reference should be made. The sequence of operations for dismantling and assembling the carburettor are given below :—

Tools

242. Three spanners are available for use on the carburettor.

Stores Ref. Section 37C.	Part No.	Description.	Classi- fica- tion.	Illus- trated in Fig.
2133	—	Spanner for float chamber cover.	F	—
2132	S.R.5758	Spanner for plugs in jet wells.	F	—
2131	S.R.3043	Jet key	F	—

Dismantling

243. (i) Remove the circlip that secures the locking plate to the cover of the float chamber and remove the locking plate.

(ii) Unscrew and remove the cover of the float chamber, using the spanner supplied (Stores Ref. 37C/2133).

(iii) Unscrew the two brass plugs on the side of the needle valve housing and remove them and the float pivot pin which is fitted to one of them.

(iv) Unscrew and remove the plug at the upper end of the needle valve housing.

(v) Invert the carburettor and allow the float to fall into the hand.

(vi) Remove the needle valve.

(vii) Unscrew the grub screw that retains the slow running device and remove the latter component.

(viii) Unscrew and remove the grub screw that retains the mixture control valve in its housing and remove the mixture control valve.

(ix) Unscrew and remove the two screws that retain the throttle valve to its spindle, withdraw the spindle and remove the valve.

(x) If necessary remove the pegs locking the bushes for the throttle valve spindle and unscrew the bushes.

(xi) Remove the studs that retain the air intake junction box to the underside of the carburettor body, and remove the junction box.

(xii) Slack off the lock nut on the tube that retains the diffuser in position and unscrew and remove the tube.

(xiii) Remove the diffuser.

(xiv) Unscrew the screw that retains the choke tube in its housing and remove the choke tube from either end of its housing.

(xv) Remove the diffuser air strainer.

(xvi) Unscrew and remove the plugs that seal the lower ends of the jet wells, using the spanner S.R.5758.

(xvii) Unscrew and remove the main and compensating jets by means of the jet key S.R.3043.

(xviii) Remove the locking ring and tab washer from the needle valve seating and unscrew the latter.

(xix) Remove the plug from the end of the fuel inlet passage, after bending back the tab of the locking washer.

Examination

244. The components must be examined as described in A/P.1464, Vol. I. Ensure that the small anti-syphoning hole, which is drilled through the wall of the housing for the mixture control cock, is not obstructed, by passing a fine steel wire through the hole into the air balance passage. If new bushes for the throttle spindle are being fitted, they must be pegged after insertion as described in A.P. 1287/D.7. The correct fuel level is 52 mm. below the top of the float chamber with the cover and fibre washer removed.

Assembling

245. (i) Place the diffuser air strainer in its recess in the choke tube housing with the tongued end nearer the lower end of the carburettor body. Enter the choke tube into its housing from either end so that its grooved end will be nearer the upper end of its housing. When sliding it home make sure that its entering end does not foul the edge of the diffuser air-strainer.

(ii) Advance the choke tube into its housing until the V-groove around its upper end is visible through the screw hole in the body, and then insert the screw and screw it home. Ensure that the screw is properly in engagement with the groove. Owing to the variation in the thickness of the casting

at the point where the screw is located, it may be necessary to face back the casting to ensure that the screw secures the choke tube effectively.

(iii) Engage the spigoted end of the diffuser in its socket in the base of the choke tube housing. Screw home the tube that locates the diffuser, and lock it with its nut. Lock the nut to the screw securing the choke tube by means of 20 s.w.g. soft brass wire as shown in A.P.1287/D.11.

(iv) Place the throttle valve in the choke tube housing so that its lower edge obstructs the mouth of the slow-running duct. Slide the throttle valve spindle home and secure it with its two screws, which must be spot-soldered to the valve.

(v) If necessary adjust the stop arm so that the lower edge of the throttle valve when in the closed position clears the wall of the choke tube housing by 0.003 in.

(vi) After fitting new fibre jointing washers, screw home the main and compensating jets, using the tube spanner S.R.3043.

(vii) After renewing their fibre jointing washers, screw home the plugs sealing the lower ends of the jet wells by means of the spanner S.R.5758. Wire the heads of these two plugs together to lock them.

(viii) Screw home the needle valve seating and secure it with its locking plate and securing ring.

(ix) Insert the needle valve into its housing but do not drop it right home. Turn the carburettor on its side so that the needle valve seating is undermost and enter the float into the float chamber, bracket side uppermost, and engage the forked end of the bracket with the bobbin of the needle valve. After fitting a new fibre washer, enter the float pivot pin through its socket and screw home the plug to which it is attached. Screw home the plug that accommodates the free end of the pin and also that which steadies the upper end of the needle valve, fitting a new fibre washer beneath the head of each. Wire together the heads of the three plugs.

(x) After renewing its fibre washer, screw home the cover of the float chamber.

(xi) Enter the mixture control valve into its housing and screw home its locating screw through the slot in its housing.

(xii) Tighten up the cover of the float chamber until the locking plate can be engaged with the hexagonal boss on the cover and with the shank of the mixture control valve, and secure the locking plate with its circlip.

(xiii) Insert the slow running device in its socket and secure it with its grub screw.

(xiv) Fit the air intake junction box to the underside of the carburettor.

Calibration of jets

246. When calibrating the jets by means of a calibrator, Mk. X (*see* A.P. 1464, Vol. I), the jets are to be inserted in the adaptors as shown in sketches 1, 6 and 16 of the illustration in the box containing the adaptors.

CHAPTER XIII

ASSEMBLING THE ENGINE

General

247. When assembling the engine all working parts must be thoroughly lubricated before being fitted, castor oil (Stores Ref. 34A/5) being employed unless the engine is going into store without test, in which case mineral oil (Stores Ref. 34A/32) must be employed. All tab washers, split-pins, circlips and locking wires must be renewed.

248. The erection of the engine is effected in three stages. Below are given the sequence of operations concerned in each stage and the manner of mounting the engine. Following these are detailed instructions for effecting the various operations.

- (i) *1st Stage. (Engine body face downwards on a low wooden trestle or erecting stand).*
 - (a) Fit the crankshaft, connecting rod assembly and fan induction casing to the engine body.
- (ii) *2nd Stage. (Engine body face upwards on a low wooden trestle or erecting stand).*
 - (a) Fit the cam drum and timing bracket.
 - (b) Set the cam drum (valve timing).
 - (c) Fit the front cover and centralise the crankshaft.
 - (d) Fit the cylinders and pistons.
 - (e) Align the cylinders.
 - (f) Fit the oil pump.
- (iii) *3rd Stage. (Engine bolted to erecting stand with crankshaft horizontal).*
 - (a) Fit the induction pipes.
 - (b) Fit the fan.
 - (c) Fit the rear cover and priming ring.
 - (d) Fit and time the magnetos.
 - (e) Fit the ignition cables.
 - (f) Fit the push rods and covers.
 - (g) Fit the sparking plugs.
 - (h) Fit and adjust the hand starter gear.

Tools

249. As many of the tools required for erecting the engine are used when dismantling the engine, and are therefore listed in Chap. IV, only the additional tools required are tabulated below.

Stores Ref. Section 36U.	Part No.	Description.	Classi- fica- tion.	Illus- trated in Fig.
4902	S.R.6198	Timing protractor ..	W·2	70
	S.R.6655	Screwed plug ..		
	S.R.6196	Washer ..		
	S.R.6194	Angle plate ..		
	S.R.6199	Distance piece ..		
4904	S.R.6197	Pointer ..	F	—
	S.R.5734	Piston position indicator.		

Fitting the connecting rods, crankshaft and fan induction casing to the engine body

250. The connecting rods, crankshaft and engine body should be in the state of assembly detailed below :—

- (i) Connecting rods.—Articulated rods fitted to the master rod and cap.
- (ii) Crankshaft.—All sealing plugs fitted and tested. Inner races of front and rear main bearings and cam drum bearings in position.
- (iii) Engine body.—Both outer races, all cylinder adaptors and the tappets and guides in position.

251. The method of fitting the rods and shaft to the engine body is as follows :—

- (i) Place the engine body face downwards on a low wooden trestle or erecting stand.
- (ii) Place the two halves of the connecting rod assembly in the engine body so that the master rod projects through the socket of No. 1 cylinder and so that the small holes in the wrist pin ends of the shanks of the articulated rods will trail when the crankshaft is turned in the direction of rotation.
- (iii) Oil the big end bearing, the outer race of the front main bearing, the crankpin and the ball bearings on the crankshaft.
- (iv) Rest the front end of the crankshaft on the internal flange in the engine body, placing a pad between it and the flange to prevent damage to the facing.

Pack the sixteen rollers around the inner race of the front main bearing and carefully lower the shaft into the engine body, working the rollers into their outer race.

- (v) Secure the connecting rod assembly to the crankpin, drawing the cap half to the master rod by means of three bolts, undersize in diameter but of standard length. If attempt is made to fit the retaining bolts without drawing the halves together by means of undersize bolts, the halves will separate slightly and the retaining bolts will bind. Having fitted the first retaining bolt, remove the undersize bolts one at a time, substituting for each bolt as it is removed, one of the retaining bolts. Ensure that each retaining bolt is fitted in its correct socket. The nuts must be split-pinned after they have been tightened by means of the long box spanner, S.R.2177. Secure the connecting rods so that they cannot fall on to the cylinder adaptors, thereby damaging both components.
- (vi) Pack the outer race of the rear main bearing with its eighteen rollers and drop it home over its inner race on the crankshaft.
- (vii) Tap the shroud washer that locates these rollers over the end of the crankshaft until it abuts against the inner race of the bearing; the drift S.R.6185 should be used.
- (viii) Lightly coat the seating on the engine body for the fan induction casing with liquid jointing compound and tallow the bore of the housing for the outer race of the rear main bearing.
- (ix) Fit the fan induction casing over its retaining studs in the engine body so that the dowel fitted to the engine body engages its hole in the fan induction casing.
- (x) Secure the casing temporarily by placing suitable distance pieces over the shanks of three of the studs before screwing home their nuts.

Fitting the cam drum and timing bracket

252. It is assumed that the cam drum bearings are in position on the crankshaft and that the timing bracket is completely assembled. The units are assembled as follows :—

- (i) Reverse the engine on the trestle or stand so that the front is uppermost.

- (ii) Raise the crankshaft by means of a lever inserted behind the web of the rear crank throw. Insert the two halves of the keeper plate of the cam drum rear bearing behind the outer race of that bearing.
- (iii) Lower the shaft so that the outer race of the bearing enters the recesses in the faces of the two halves of its keeper plate.
- (iv) Slide all the tappets outwards as far as possible.
- (v) Tallow the bearing housing of the cam drum unit and pass the unit over the end of the crankshaft, engaging the bore of the housing around the outer race of the rear bearing.
- (vi) Pass the bush S.R.6686 (*see* fig. 58) over the end of the crankshaft. Engage its spigoted end in the mouth of the bearing housing and tap the bush and the cam drum unit home with the tubular drift S.R.6185, until the front lip of the bearing housing stands $\frac{3}{16}$ in. proud of the outer race of the front bearing. When this occurs, remove the drift, reverse the bush, and drive the assembly right home.
- (vii) Register the holes in the cam bearer flange with those in the two halves of the bearing retaining plate behind it. Fit the retaining screws and split pin each in position.
- (viii) Fit the key for the driving sleeve in its key-way in the crankshaft.
- (ix) Fit the shims that were previously employed over the retaining studs for the timing bracket.
- (x) Lower the timing bracket over the end of the shaft, but do not bed it right home.
- (xi) After tallowing its bore, pass the driving sleeve over the end of the shaft and engage its key-way with the key in the crankshaft.
- (xii) Drive the sleeve to within $\frac{1}{4}$ in. of its proper position, using the tubular drift S.R.6185, at the same time holding the bracket with its idler wheels in engagement with the sleeve.

Setting the cam drum (valve timing)

253. Before the operation of timing the valves can be commenced it is necessary to fit the timing protractor and pointer to the engine (*see* fig. 70) and also to fit No. 1 cylinder. The timing protractor S.R.6198 must be secured to the front end of the crankshaft by means of the screwed plug S.R.6655, the washer S.R.6196 being interposed between the plug and

the protractor. The angle plate S.R.6194 must be attached to one of the studs by which the front cover is attached to the engine body, the small distance piece S.R.6199 being mounted at the back of the angle plate. The pointer S.R.6197 must be adjusted on the angle plate so that it just clears the circumference of the protractor.

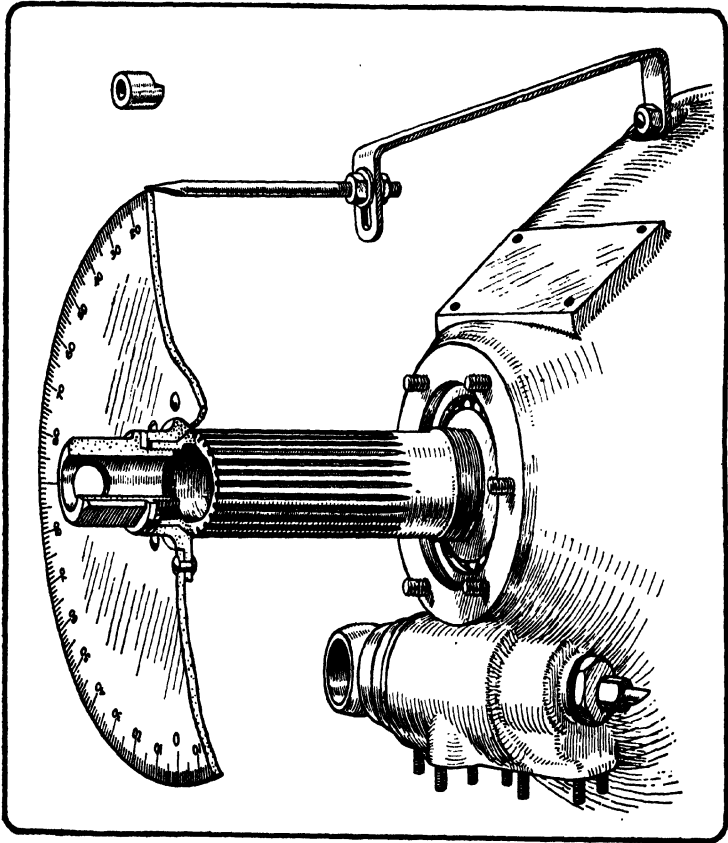


FIG. 70. Timing protractor and pointer.

254. No. 1 piston and cylinder must now be fitted by the method described in para. 256. The piston position indicator S.R.5734 must be fitted in the centre adaptor in the cylinder head. The procedure for valve timing is then as follows:—

- (i) Turn the crankshaft by means of the eyebolt until the piston is on T.D.C. Set the timing protractor to zero and lock it in position. Owing to the lack of

- sensitivity of the piston position indicator when the piston approaches T.D.C., the setting of the timing protractor must be checked as described below.
- (ii) Turn the crankshaft about 20° past zero, reverse the direction of turning to reduce the reading to 10° , and mark the position of the pointer of the piston position indicator. Turn the crankshaft about 20° past zero on the opposite side and reverse the direction of turning, so as to approach zero. When the pointer of the piston position indicator again registers with the mark made in the previous instance, take the reading of the timing protractor. Halve the difference between this reading and 10° , turn the crankshaft until the timing protractor pointer indicates zero, and reset the pointer, on the same side of zero as the greater reading, to the half difference calculated above.
 - (iii) Fit an inlet push rod to the cylinder and set the tappet clearance to 0.010 in.
 - (iv) Disengage the timing wheel bracket from the driving sleeve and turn the cam drum unit in an anti-clockwise direction until No. 1 inlet cam, which has the part number marked upon it, is just about to lift the inlet valve tappet of No. 1 cylinder.
 - (v) Lower the timing bracket and turn the gear wheels into the best position for engagement with the annulus and driving sleeve. It may be necessary to turn the crankshaft slightly to effect actual engagement; the amount which it should be turned must not exceed $2\frac{1}{2}^\circ$ in either direction.
 - (vi) Secure the timing bracket sufficiently tightly for it to be necessary to tap it in order to move it about its retaining studs.
 - (vii) Turn the crankshaft through six revolutions in short stages, stopping frequently to test the backlash of the idler wheels (*see* paras. 214 and 215). It is essential that there should be the correct backlash in every position. If the wheels are at all tight the gear will work harshly and will probably suffer damage when run. The depth of mesh may be adjusted by tapping the bracket sideways over its studs. It must be possible to turn the crankshaft through six complete revolutions without any tight spots occurring.
 - (viii) Having adjusted the mesh, tighten down the nuts that retain the bracket, and check the timing. If necessary repeat the above operations until the timing is correct to within $2\frac{1}{2}^\circ$.

- (ix) Remove the timing protractor and pointer. Tap the driving sleeve home by means of a tubular drift. Again check the backlash of the timing gears (*see* paras. 214 and 215). Secure the sleeve with the crankshaft rear lock nut and tab washer. When fitting the tab washer, see that the internal tab (which should be bent downwards) cannot hang up on the end of its groove beneath the driving sleeve. The lock nut must be driven hard home by hammer blows applied to a tommy bar taken through its box spanner S.R.5621 or S.R.11569, before its tab washer is bent up. Before fitting the washer it is advisable to radius the lower surface of the outer tabs slightly. This will permit a chisel to be engaged beneath them when it is desired to bend the tab up.
- (x) Remove No. 1 cylinder and piston by the method described in para. 140.

Fitting the front cover and centralising the crankshaft

255. Before fitting the front cover, the breathers and baffles must be replaced and the components of the thrust bearing assembled as described in para. 198. The procedure is then as follows :—

- (i) Pour oil liberally over the tappet guides and cam gear.
- (ii) Lightly coat the jointing face of the front cover with liquid jointing compound and fit the cover over its studs. Drive it home by means of the tubular drift S.R.6182, which should be passed over the end of the crankshaft so as to bear on the inner race of the roller bearing in the thrust housing. Screw home the front cover retaining nuts, placing a tab washer beneath each.
- (iii) Screw the crankshaft front lock nut home, using the box spanner S.R.5621 or S.R.11569. The nut must be driven up hard by blows from a hammer applied to a tommy bar through the spanner. The nut is eventually locked by the rear centring cone of the airscrew hub.
- (iv) Sling the engine from an eyebolt screwed into the front end of the crankshaft so that the weight of the crankcase is taken by the crankshaft. The latter will then be in its fully forward position. Check the centring of the big end of the master rod in the cylinder socket, using an internal micrometer between the cheeks of the gudgeon pin end of the master rod and the bore of the cylinder socket. The weight of the rod must be taken by

the hand whilst the measurements are being made to prevent errors arising owing to the tilt of the rod on the crankpin. Two readings must be taken, one with the big end of the rod raised on the pin as far as possible and one with the big end dropped on the pin as far as possible ; the mean must then be calculated. Should the maximum permissible error be exceeded, it must be corrected by removing the adjusting washers from the thrust housing and replacing them by others of suitable thickness. In no case may the total thickness of the adjusting washers be varied. For example, if the thickness of the washer fitted between the rearmost distance piece and the back of the thrust housing has to be reduced by 0.010 in. because the crankshaft is 0.010 in. too far forward, the thickness of the washer fitted between the outer race of the roller bearing and the thrust housing cover plate must be increased by 0.010 in. The reason for this is explained in para. 197, sub-para. (viii).

- (v) When the crankshaft has been centralised correctly, locked the nuts securing the front cover to the engine body and the thrust housing cover plate to the front cover by bending up the tab washers.

Fitting the pistons and cylinders

256. It is assumed that each piston is fitted with its rings and one gudgeon pin circlip and that the cylinders are fitted with their valves, springs, rockers and inner portions of the rocker casings. The gas starter valve adaptors and sparking plug adaptors should be blanked off with blanking plugs and dummy sparking plugs respectively. One of the latter, in each cylinder, must not be airtight. No. 1 piston and cylinder must be fitted first, for the reasons stated in para. 140. The sequence of operations is as follows :—

- (i) Turn the crankshaft until the rod serving the piston to be fitted is on T.D.C. and fit the piston so that the number stamped on its crown is nearest the front of the engine. Oil the gudgeon pin and slide it home, securing it with a circlip. Ensure that the gudgeon pin floats in the piston bosses and space the gaps in the piston rings at 180° to each other.
- (ii) Set the gap of the barrel locking ring of the appropriate cylinder to between $\frac{3}{8}$ in. and $\frac{1}{2}$ in. Coat the skirt of the piston and the cylinder bore with lanolin (Stores Ref. 33C/511) and slide the cylinder carefully into position, taking care to ease the

piston rings into the cylinder. Screw the cylinder into its adaptor in the engine body, at the same time oscillating the piston by turning the crankshaft to and fro through an angle of about 45° on each side of T.D.C. This movement of the piston prevents circumferential scoring of the cylinder barrel by the piston rings. When the cylinder binds on its locking ring, turn it through the lesser arc to bring its valve ports square and to the rear of the engine.

- (iii) Tighten the locking ring bolt by means of the spanner S.R.2589 until the cylinder can just be turned by hand.

Fitting a new cylinder or one for which the seating in the engine body has been refaced

257. In both the above cases it will probably be found that when the cylinder is screwed home as described in operation (ii) of para. 256, the valve ports will not face towards the rear of engine unless the gap in the barrel locking ring is increased or decreased beyond the limits of $\frac{3}{8}$ in. and $\frac{1}{2}$ in. Should this occur, the following procedure must be adopted :—

- (i) Make a chalk mark on the cylinder socket in the engine body immediately below the gas starter valve adaptor and remove the cylinder (*see* para. 140).
- (ii) Make a chalk mark in the bore of the cylinder adaptor to correspond with that on the engine body.
- (iii) Remove the adaptor locating screw and turn the adaptor in its socket until the chalk mark in the bore of the adaptor faces as nearly forward as is consistent with one of its locating holes being engaged by the locating screw.
- (iv) With the adaptor in this position fit the locating screw and tighten it.
- (v) Refit the cylinder as previously instructed.

Aligning the cylinders

258. The alignment of the cylinders should be effected by placing a straightedge across the inlet port flanges of each pair of adjacent cylinders in turn, working from No. 1 in the order of numbering. Where an error in alignment between two cylinders is found, turn the cylinder in error (as opposed to the cylinder already checked against an earlier cylinder) so as to bring the flanges concerned into alignment. The alignment may be considered correct if, when the straightedge is placed across the inlet port flanges of cylinders Nos. 1 and 7 an error of not more than 0.02 in. exists at the conclusion of the test.

Should a final error of an amount greater than that stated be found to exist between cylinders Nos. 1 and 7, the flanges of those cylinders must be aligned by turning the two cylinders by an equal amount, after which the test must be repeated.

259. After completion of the alignment, tighten the barrel locking ring screws with the spanner S.R.2589, using no more force than can be applied by one hand. If undue force is used, there is a danger of bending the locking ring screws. Whilst tightening the locking screws, the backs of the locking rings should be tapped with a soft drift to prevent them from binding in their grooves and giving a fictitious impression of tightness.

Fitting the oil pump

260. Place an Alcumite washer between the oil pump and its seating on the front cover. It may be necessary to turn the crankshaft through a small angle to enable the pump skew gear wheel to mesh with the skew gear pinion on the driving sleeve. Having engaged the wheel, place a tab washer beneath each of the retaining nuts and bolt-heads of the pump casing, screw them home, and lock them. Fit the oil pipe between the scavenge pump and the union beneath the engine body. It is most important that this pipe should be an accurate fit between its two unions. The union fitted beneath the engine body is liable to fracture when the engine is running under the strain caused by an incorrectly fitting pipe.

Fitting the induction pipes

261. Before fitting the induction pipes the engine must be lifted off the trestle by the eyebolt, which should be screwed into the end of the crankshaft. Lower the engine on to the erecting stand and bolt it to the ring plate. Swing the stand and lock it so that the crankshaft is horizontal. The procedure is then as follows :—

- (i) After ensuring that all the gland nuts around the fan induction case are loose and that the Dermatine packings and duralumin washers are positioned correctly, work the induction pipes into their sockets until the union nuts at the outer ends may be engaged with the inlet port flanges.
- (ii) Place a new copper-asbestos washer between the end of each induction pipe and its flange, screw home the ring nut by means of the spanner S.R.5593 and lock the nut with its circlip.
- (iii) Tighten the gland nuts around the fan induction casing, using the same spanner as before, and secure them with the locking plates. The heads of the two bolts securing each locking plate must be locked with wire.

Fitting the fan

262. The seating of the fan gland having been checked as described in para. 218, the fan should be fitted as follows :—

- (i) Mount the gland on the hub of the fan with the four compression springs in place between the two components.
- (ii) Place a suitable tubular drift over the end of the crankshaft and tap the rear bearing as far forward in its housing as possible.
- (iii) Place over the end of the crankshaft the shims previously employed and enter them into the mouth of the rear bearing housing.
- (iv) Turn the crankshaft until the fan key-way is uppermost.
- (v) Fit the fan on the shaft so that its key-way tracks with that on the crankshaft. It should be slid home with a steady hand pressure. No jarring or tapping home of the fan must be permitted. Should the fan be jarred, its gland may set forward on the hub, and if this should occur there is a danger of losing one or more of the springs. These would fall down behind the fan and their loss might not be noticed until they found their way into the valve ports.
- (vi) Place a tab-washer over the end of the crankshaft and screw home the fan nut.
- (vii) Check the clearance between the fan and the radiused portion of the fan induction casing. If the clearance is incorrect it must be adjusted by varying the number or thickness of the shims fitted between the fan hub and the rear bearing.
- (viii) Remove the fan nut and tab washer.
- (ix) Tap the fan key into its key-way in the fan and crankshaft. It is essential that the key should be a fairly light tapping fit in its key-way. If it is tight there is a danger of its distorting the fan boss and thus binding the fan gland. There would also be a possibility of its setting the fan over on the end of the crankshaft.
- (x) Fit the tab-washer over the end of the crankshaft, having first bent one of the tabs of the washer to engage one of the extractor holes in the hub of the fan. Screw the nut up, driving it home by hammer blows applied to a tommy bar passed through the box spanner S.R.5625. Bend up one of the tabs of the washer between the castellations of the nut.

Fitting the rear cover

263. Unscrew the nuts temporarily fitted to the fan induction casing retaining studs (*see* para. 251, sub-para. (x)). Lightly coat the jointing face of the rear cover with liquid jointing compound and fit it over its studs. Ensure that the dowel fitted in the casing will engage the dowel hole in the rear cover. Tap the cover home on to its seating with a few blows from a hide hammer. Fit the priming ring so that the union to the priming pump is uppermost. One of the retaining clips for the priming ring is positioned on the lowest stud securing the rear cover to the fan induction casing, the remainder of the clips, of which there are seven altogether, being fitted on alternate studs. Secure the priming ring and rear cover by means of nuts screwed on to the studs ; a spring washer must be placed beneath each nut. Fit the branch pipes to the priming ring but do not connect them to their bosses in the inlet ports.

Fitting and timing the magnetos

264. (i) Mount the two magnetos on their seatings, fitting the same shims as were previously employed. A spring washer must be fitted beneath each nut. It is essential to fit the magnetos to their original seatings, otherwise the adjustments for the depths of mesh of their bevel wheels will be upset.

(ii) Fit the magneto drive shaft assembly to the rear cover, engaging the splines at its front end with those in the crankshaft and meshing its bevel wheel with those of the magnetos. Secure the bearing housing to the rear cover with two nuts and spring washers. At this stage the wheels may be engaged in any position and the backlash between the magneto drive shaft and the crankshaft tested as described in para. 228.

(iii) Check the backlash between the magneto bevel wheels and the magneto drive shaft bevel wheel as described in para. 229. The method of obtaining the correct amount of backlash is also described in that paragraph.

(iv) Remove both magnetos and fit the timing protractor to the front end of the crankshaft, the timing pointer to one of the studs securing the front cover to the engine body, and the piston position indicator to No. 1 cylinder.

(v) Set the crankshaft on T.D.C. by the method described in para. 254, sub-paras. (i) and (ii) and turn the crankshaft until the piston of No. 1 cylinder is 37° before T.D.C. on the compression stroke. As the push rods have not yet been fitted it must be ensured that No. 1 piston is on the compression stroke by noting that both tappets are at the innermost extremities of their travel.

(vi) Hold the distributor gear wheel of the port magneto so that the distributor arm is serving No. 1 cylinder and the contact breaker points, correctly adjusted, are just about to open, and offer it up to its seating on the rear cover, turning its spindle by the least amount necessary to effect engagement of its bevel wheel with that of the magneto drive shaft. Secure the magneto to its seating.

(vii) Check the timing of the magneto by the lamp and battery method. The maximum permissible error in timing is 1° on either side of T.D.C. Should this tolerance be exceeded, the magneto must be removed and re-timed. If the timing is more than 8° out, it can possibly be corrected by altering the mesh of the magneto bevel with that of the drive shaft by one tooth. Should the error be less than this it will be necessary to remove the magneto bevel wheel and set it round by one or more key-ways on its spindle, as specified below :—

<i>Error to be corrected, in degrees.</i>	<i>Number of key-ways through which bevel wheels must be moved.</i>				
1.71°	2
3.43°	4
5.14°	1
6.86°	3

(viii) The bevel wheel is moved on its taper in the opposite direction to that in which it is desired that the adjustment should be made. That is to say, if it is desired to advance the timing by a certain amount, the bevel wheel is turned on the shaft in a direction opposite to that of its normal rotation. When the wheel is re-engaged with the magneto drive shaft bevel wheel, it must be turned in the direction of normal rotation until its teeth mesh. The tool supplied for withdrawing the bevel wheel and its use are described in para. 240.

(ix) Having checked and corrected the timing of the port magneto, turn the crankshaft in the direction of rotation through 5° until the piston of No. 1 cylinder is at 32° before T.D.C. and repeat operations (vi), (vii) and (viii) on the star-board magneto.

(x) Having fitted and timed the magnetos, remove the timing protractor and pointer. Fit the engine speed indicator drive unit, interposing the shims previously used between it and its seating. Place a spring washer beneath each nut. .

Fitting the ignition cables

265. If the ignition cables have not been separated from their clips and magneto distributor covers, they may be fitted as a unit, as instructed below :—

- (i) Insert the sparking plug end of each cable through its respective hole in the engine bearer, secure the distributor covers to the magnetos and draw the cables through the holes in the engine bearer until the cables are correctly positioned (*see fig. 30*).
- (ii) Loosen the cable clamps on the cylinder heads and engage the cables in the clamps so that no cable requires to be crossed over another before being taken to its respective sparking plug. The cables having red identification sleeves serve the sparking plugs beneath the inlet valves. Tighten the bolts securing the clamps after allowing sufficient cable for attachment to their respective plugs in an easy sweep.
- (iii) Secure the cables and priming pipes to the induction pipes with the steel straps and aluminium split clamps. The straps are located at each end of the induction pipes.
- (iv) Connect the bonding wires to the studs securing the hand starter gear to the rear cover.

Testing the induction and priming systems for leaks

266. Before fitting the push rods a test should be made to determine whether there are any air leaks in the induction system and whether the fan gland is seating correctly. The test consists of blowing smoke into the gas passage in the rear cover and observing whether smoke leaks from any of the induction pipe joints or from the breathers. The test is effected at the completion of the erection of the engine. The apparatus employed is either an old heater box, specially prepared, or a canister which should be made up according to the sketch shown in fig. 71. The heater box is prepared by having a plate permanently fitted to its under-surface so as to blind the duct to the carburettor. A pipe from which a flexible connection may be taken to a cylinder of compressed air is brazed into this plate and delivers to the gas passage in the rear cover. The mouth of the duct at the upper end of the heater box is recessed, and accommodates a disc drilled with numerous small holes. The disc acts as a grid to prevent particles of burnt rag from being blown into the engine, and is retained by a stud attached to the plate on the under-side of the heater box. The construction of the canister, which

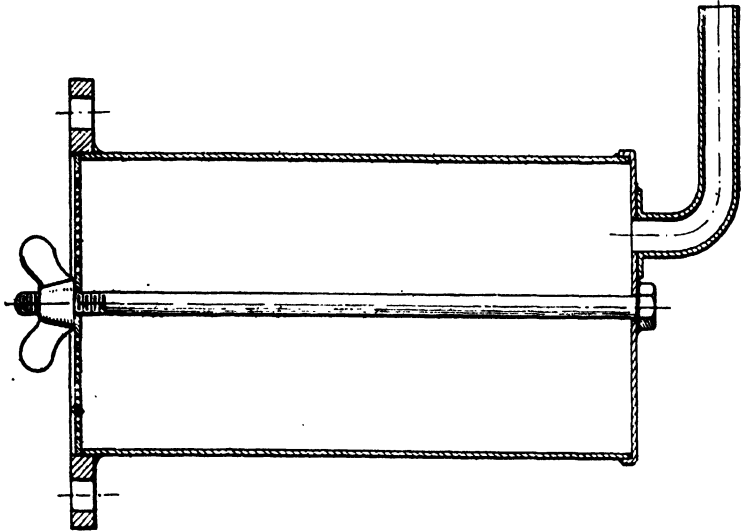


FIG. 71. Canister for smoke test.

should be made up only if an old heater box is not available, is obvious from the sketch. Either component is used as follows :—

267. An amount of rag which can be conveniently filled into either the heater box or the canister, is soaked in oil or paraffin and then lit and the flames extinguished. When smouldering strongly, it is dropped into the heater box or canister, and the pierced lid secured in position. The heater box or canister is then secured to the under-side of the rear cover. A fibre or other soft washer is employed to render the joint gas-tight. A flexible rubber connection from the air container is attached to the pipe at the under-side of the heater box or canister. The air is turned on and smoke will emerge from any leaky joints. If the fan gland is not seating correctly, smoke will emerge from the breathers.

268. It is desirable to test the priming system in a similar manner, the source of supply of smoke being connected to the union at the top of the priming ring. Having seen that smoke issues from the ends of all six branch pipes, connect the latter to their elbows in the inlet ports.

Fitting the push rods and covers

269. The first operation in fitting the push rods and covers is to assemble each pair of rods, springs, covers and the bracket as instructed below :—

- (i) Place a spring-retaining sleeve over each push rod and insert the rod into its respective cover tube,

Fig. 24 indicates the disposition of the rods in the cover tubes. The caps riveted to the outer ends of the cover tubes and the push rods are marked to facilitate assembly.

- (ii) Place a spring over the outer end of each push rod and then fit a spring retainer in the outer end of each cover tube, turning the retainer after it has been inserted until it can be felt that the lugs projecting from it have engaged the recesses in the interior of the cap riveted to the cover tube.
- (iii) Fit the cover tubes to their respective brackets; the tubes are to be inserted into the brackets as far as possible.

270. The assembled push rods and covers are next fitted to the engine as follows, the joints between the brackets and tappet guides being made with liquid jointing compound :—

- (i) Turn the crankshaft until the pair of tappets to be fitted with push rods are at the innermost extremities of their travel.
- (ii) Remove the rocker sockets and clamping screws from the rockers to be fitted with push rods.
- (iii) Pass the outer ends of the push rods through the holes for the rocker sockets in their respective rockers.
- (iv) Engage the forked end of one of the levers S.R. 22535 with the tappet-operated end of the exhaust push rod (*i.e.*, the rod having the tappet-operated end near the cylinder) and force the rod outwards, until the further end projects through the hole in the rocker for the socket. Engage this latter end of the push rod with the forked end of the second lever S.R. 22535, so as to prevent the rod from springing back when the first lever is released. Steady the second lever against the chest and shoulder so that it may be released by the hand, and then remove the first lever from the tappet-operated end of the rod. The use of the second lever may be dispensed with if the push rod is held in the desired position with the stirrup shown in fig. 72. The stirrup is used to straddle the end of the valve rocker and receives the end of the push rod in the countersunk end of the slot. Engage the first lever with the tappet-operated end of the inlet push rod and use this to force the rod outwards so that it may be swung into engagement with the inlet tappet, the free hand being used to steady the push rod unit whilst this is being done. Next

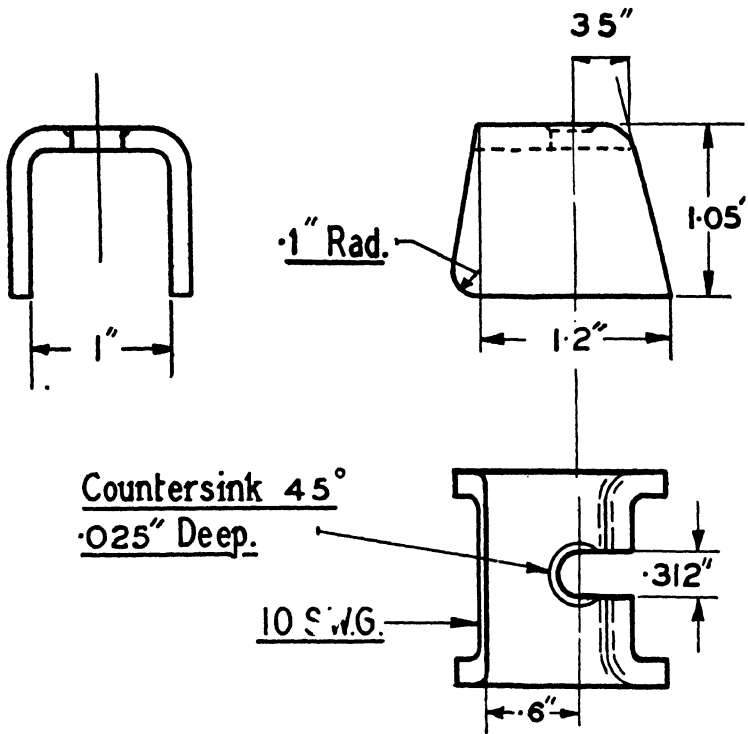


FIG. 72. Stirrup for holding push rod.

swing the push rod unit round on the inlet valve push rod, until the tappet end of the exhaust push rod lies over the exhaust tappet, and then release the lever or stirrup engaged with the rocker-operating end of that rod. Owing to the angularity of the rods and cover tubes, this second rod will not immediately spring into engagement with the tappet, but will do so as soon as the bracket is tapped down over the ends of the tubes and on to the studs by which it is retained to the tappet guide.

- (v) Retain the unit to the tappet guide with the nuts, which are to be secured with split-pins; washers are to be fitted beneath the nuts. Before tightening the nuts, see that the assembly marks on the flange of the tappet guide and on the engine body are in alignment, and, if necessary, raise the bracket and tap the guide round into the desired position.

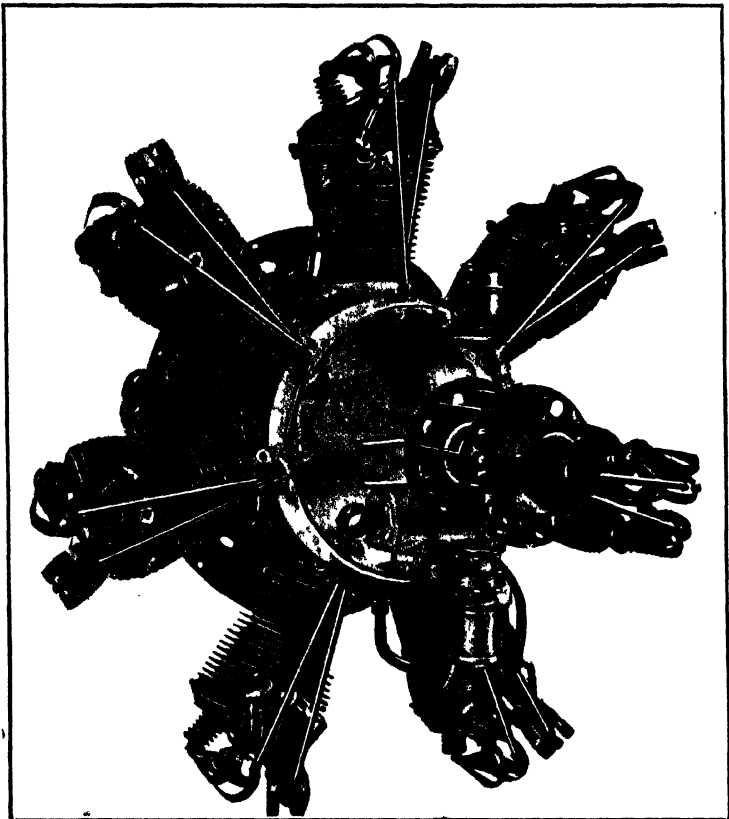
- (vi) Twist each cover tube around its push rod, until it is felt that the recesses in its outer end are in engagement with the rivet heads beneath the rocker casing.
- (vii) Fit all sockets and clamping screws to the rockers and adjust the clearances with the gauge provided, after which replace the outer portions of the rocker covers.

Fitting the sparking plugs

271. Remove all dummy plugs and substitute the specified sparking plugs, smearing the threads with graphite grease and fitting new copper-asbestos washers. Connect the ignition cables to their respective leads, using A.G.S. terminal adaptors.

Fitting the hand starter gear

272. Fit the hand starter gear to the back of the rear cover, using liquid jointing compound between the two components and placing a spring washer beneath each nut. Adjust the starter as described in paras. 135 and 136.



Frontispiece Three quarter front view of engine

APPENDIX No. 1

LYNX IV (MOD.) AERO-ENGINE

LEADING PARTICULARS

General.

Type	Air-cooled static radiator.
Number of cylinders	7.
Bore	5 in.
Stroke	5½ in.
Compression ratio	5 to 1.
Reduction gear	None.
Direction of rotation of crankshaft ..	Left-hand tractor.
Normal r.p.m.	1700.
Maximum r.p.m.	1870.
B.H.P. at normal r.p.m.	187-195.
B.H.P. at maximum r.p.m.	200-210.
Numbering of cylinders (looking at front of engine)	1 to 7, clockwise. No. 1 vertical.

Lubrication.

Oil specified for summer and winter use	To Specification D.T.D. 109.
Oil consumption	3-8 pints per hour.
Normal oil pressure	75 lb. per sq. in.
Minimum oil pressure	60 lb. per sq. in.
Oil inlet temperature	70° C.
Oil outlet temperature	75° C.

Carburation.

Fuel specified	To Specification D.T.D. 224.
Fuel consumption at normal r.p.m. ..	14.25 galls. per hour.
Type of carburettor	Zenith, type 65G.
Main jet calibration	600 c.c. per min.
Compensating jet calibration	340 c.c. per min.
Slow running jet calibration	140 c.c. per min.
Choke tube, bore	42 mm.

Ignition.

Type of magnetos	B.T.H., S.C.7-1 (Fixed timing).
Port magneto timing	37° before T.D.C.
Starboard magneto timing	37° before T.D.C.
Firing order	1, 3, 5, 7, 2, 4, 6.
Direction of rotation of magnetos (looking at contact breaker) ..	Clockwise.
Magneto speed	¾ engine speed.
Sparking plugs	As specified in Air Publication 1260.

Valve timing.

All valve tappet clearances (hot) ..	0.060 in.
All valve tappet clearances (cold) ..	0.002 in. to 0.006 in.
Inlet valve opens with hot tappet clearance	1½° before T.D.C.
Inlet valve closes with hot tappet clearance	41½° after B.D.C.
Exhaust valve opens with hot tappet clearance	51° before B.D.C.
Exhaust valve closes with hot tappet clearance	11° after T.D.C.

Installation.

Overall diameter of engine	46 in.
Overall length of engine	44.3 in.
Pitch circle diameter of engine bearer bolt holes	25 in.
Number of mounting bolt holes	16.
Diameter of mounting bolt holes	⅝ in.

PART I

DESCRIPTION

tion

a). The Lynx IV (Mod.) aero-engine is a Lynx IV aero-engine adapted to a standard between that of the latter engine and the latter engine. It differs from the Lynx IV* in the following components:—

- Cylinders
- Pistons
- Front cover
- Valve operating gear
- (v) Induction pipes
- (vi) Priming system
- (vii) Airscrew hub.

2. Descriptions are given below of the above components or attention is drawn to the points in which they differ from the corresponding components of the Lynx IV* engine. Information is also given concerning any differences that may be necessary in the maintenance and overhaul of the engine. All references apply to this appendix only unless otherwise stated.

Cylinder unit

3. The cylinder unit is somewhat similar to that fitted to the Lynx IV* engine, the cast aluminium head being screwed and shrunk to a mild steel barrel; the head is locked to the barrel and the barrel is attached and locked to the engine body as described in paras. 4 and 5 of the handbook.

4. The most apparent differences between this cylinder, which is shown in fig. 1, and that previously described are the absence from the earlier cylinder of the rocker bracket, rocker covers and bolted-on inlet and exhaust port flanges. The rocker bracket is replaced by a platform cast at the front of the cylinder head; this platform does not provide compensation of the valve tappet clearances, and hence cylinder expansion has a considerable effect on the clearances. Each valve rocker is unenclosed and is mounted in a steel fork attached to the cylinder head by a castellated nut and a stud integral with the fork. The latter is prevented from turning by a dowel. The induction and exhaust pipes are each attached to a twin-studded flange: no boss for a priming elbow is provided in the inlet port. The shapes of the combustion chamber and gas passages differ slightly from those of the later type of cylinder head, but the disposition of the valves, valve seats, and adaptors for sparking plugs and gas starter non-return valves is the same.

5. In general shape the rockers are similar to those of the Lynx IV* engine, but have hardened steel plugs pressed into the push rod operated ends; these plugs are not adjustable. Each rocker is mounted upon a pair of ball bearings which are lubricated through a grease gun nipple screwed into the end of the rocker fulcrum pin. Each rocker is retained in contact with the push rod by a pair of auxiliary springs of the grasshopper type. These are anchored at their inner ends in holes drilled in the rocker platform in the cylinder head and at their outer ends against a pin pressed through the valve operating end of the rocker. They are steadied near their centres by a pin pressed into the shank of the fork in which the rocker is mounted.

Piston

6. With the exception that the crown is flat instead of concave, the piston is almost identical with that fitted to the Lynx IV* engine.

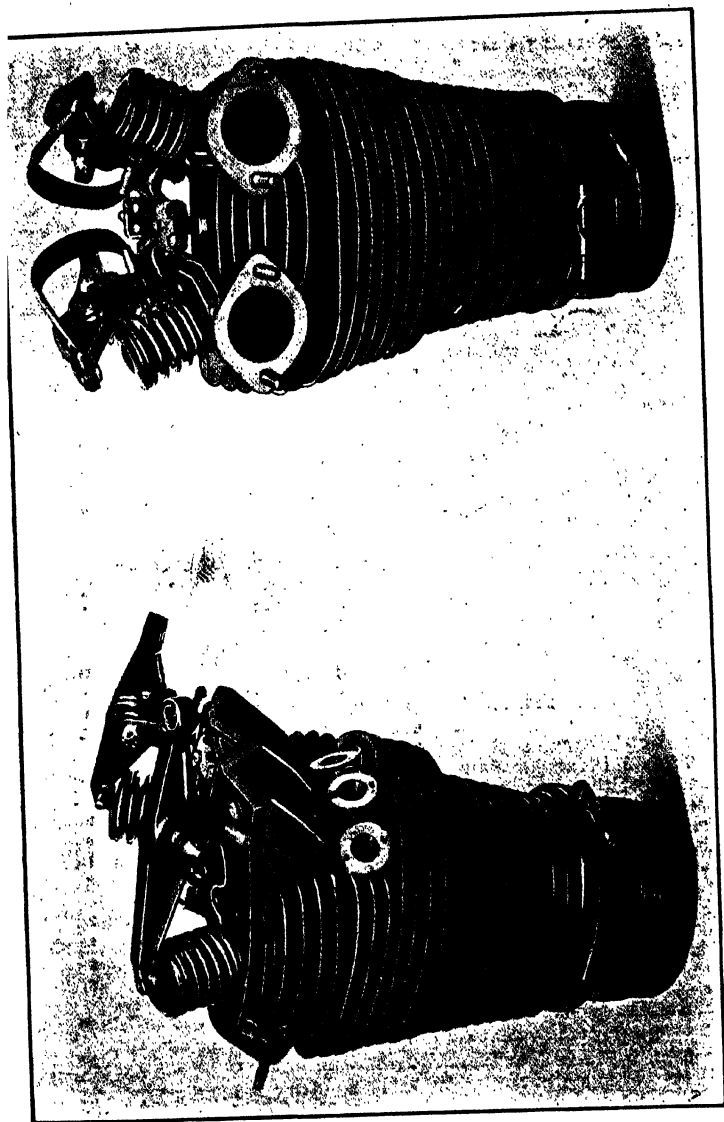


Fig. 1. Cylinders.

Front cover

7. Most engines will be fitted with the earlier type of front cover, described in para. 37 of the main portion of the handbook.

Valve operating gear

8. The cam drum unit and its drive are identical with that of the Lynx IV* engine, with the exception that the cam contour is different. Also, on some engines, a less robust cam bearer is fitted; this component is not provided with a thread around its sleeved portion for extraction purposes.

9. The push rods and rockers being unenclosed, a different type of bolt is used to secure the tappet guides in the engine body. This bolt is shorter than that fitted to the IV* engine and has no extension beyond the head. Owing to the absence of this extension no slots are machined in the tappet guide for its accommodation.

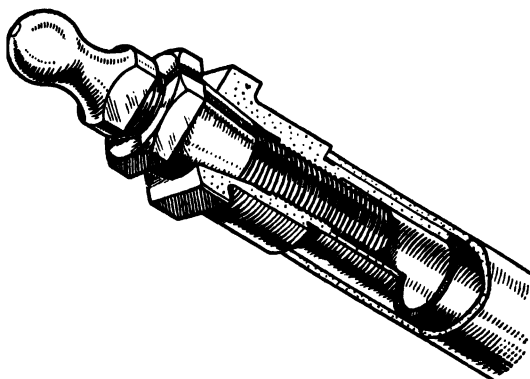


FIG. 2. Adjustable end of push rod.

10. The push rods differ from those previously described and are adjustable in length. Each rod has a tubular steel body into the inner end of which a case-hardened ball-ended plug is soldered. An internally threaded sleeve is soldered into the other end of the rod for the reception of a ball-ended tappet as shown in fig. 2. A hexagonal flange is formed around the outer end of the sleeve, which is bored taper to accommodate the conical end of a split nut carried on the tappet. This nut, when once the tappet has been set to give the correct clearance, is screwed down the shank of the tappet into the mouth of the sleeve and is thus clamped firmly around the tappet. All push rods are marked on the sockets at the outer ends of the rods for the cylinder and valve to which they are to be fitted.

Induction pipes

11. The induction pipes, instead of being in one piece, are each constructed in two portions from mild steel tube. The inner portion is received in a gland in the fan induction casing as described in para. 39 of the handbook. A lipped sleeve is welded around the outer end of the inner portion of the pipe. The lip is engaged by the internal lip of a union nut which effects the attachment of the outer portion of the pipe. The latter has a threaded collar welded to its inner end and a flange, incorporating a priming nipple, welded to its outer end. The threaded collar is engaged by the union nut mounted on the shank of

the inner portion of the pipe. The nut draws the ends of the two portions of the pipe into contact with a copper-asbestos washer which seals the joint between them. This nut is locked by a circlip. Two studs and nuts fitted to the cylinder head retain the flanged end of each induction pipe to the inlet valve port, an Amabestine washer being interposed between them.

Priming system

12. The priming system is identical with that fitted to the Lynx IV* engine except that the branch pipes are slightly shorter.

Airscrew hub

13. Some Lynx IV (Mod.) engines are fitted with the earlier type of airscrew hub as described in para. 114 of the main portion of the handbook. An airscrew hub fitted with one of the early type spiders is shown in the frontispiece to this appendix.

PART II

MAINTENANCE AND OVERHAUL NOTES

Tools

14. The following tools, some of which are not supplied with the Lynx IV* engine are necessary for the maintenance and overhaul of the Lynx IV (Mod.) engine.

Stores Ref. Section 36U.	Part No.	Description.	Classi- fica- tion.	Illus- trated in Fig.
4903	S.R.5661	Valve tappet clearance gauge (cold).	F	—
4957	S.R.5662	Valve tappet clearance gauge (hot)	F	—
4913	S.R.6083	Spanner for push rod clamping nut.	F	—
4912	S.R.5586	Spanner for ball-end of push rod.	F	—
4915	S.R.6084	Spanner for hexagon on push rod.	F	—
4906	S.R.4800	Lever for lifting rocker ..	F	—
		EXTRACTOR FOR EARLY TYPE CAM DRUM, <i>consisting of</i> :—		
4944	S.R.2132	Draw bolts (2 off) ..	} W-1	4
4949	S.R.2136	Yoke plate (1 off) ..		
4958	S.R.2122	Plug for front end of crankshaft (1 off).		
4961	S.R.5622	Ring plate (1 off) ..		
4964	S.R.2123	Extractor screw (1 off) ..		

Checking and adjusting valve tappet clearances

15. The tappet clearances for each cylinder must be checked with the gauge S.R.5661 if the engine is cold or S.R.5662 if the engine is hot. The piston of the cylinder being worked upon must be at T.D.C. on the power stroke, when both valves will be closed. To adjust the clearance, slacken the clamping nut of the adjustable push rod, using the spanner S.R.6083, and screw the ball-end into or out of the socket in the push rod by means of the spanner S.R.5586 until the desired clearance is obtained between the rocker striking pin and the end of the valve stem. The push rod may be prevented from rotating during this operation by holding the hexagon at its outer end with the spanner S.R.6084. After adjustment of the ball-end, tighten the clamping nut. When both push rods of any cylinder have been adjusted, the tappet clearances of the cylinder next but one to it in a clockwise direction may be adjusted if the airscrew is turned through an angle of about 100° in the same direction.

Lubrication of the rocker sockets

16. To lubricate the joints between the rocker sockets and the ends of the tappet rods, the rockers must be lifted by means of the lever S.R. 4800 or the tool illustrated in fig. 3. The push rods may

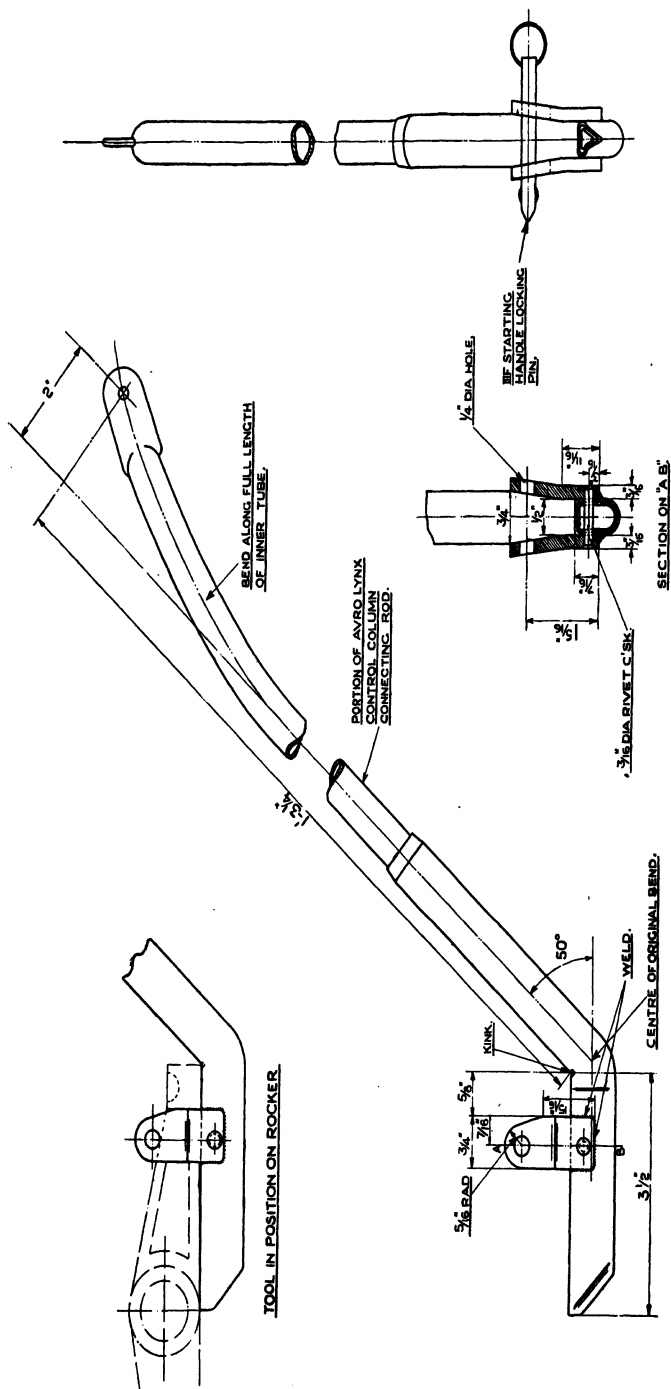


FIG. 3. APPENDIX NO 1
VALVE ROCKER LIFTING TOOL.

then be removed and the ends greased liberally. When lowering the rocker ensure that the ball-end of the push rod enters the rocker cup and seats correctly. Remove all surplus grease.

Checking the rocker cup for wear

17. If the ball-end of the push rod wears through the hardened surface of the rocker cup, rapid wear of the latter takes place, resulting in the neck of the ball-end fouling the side of the cup. The depth of the cup should be checked by means of the gauge illustrated in A.P.1287/C5, in which leaflet the use of the gauge is also described.

Cylinder unit

18. Overhaul of the cylinder unit is very similar to that of the Lynx IV* cylinder. If the spring testing rig H.A.D. 171 is used for testing the valve springs, care must be taken to use the correct gauge. All rockers are interchangeable.

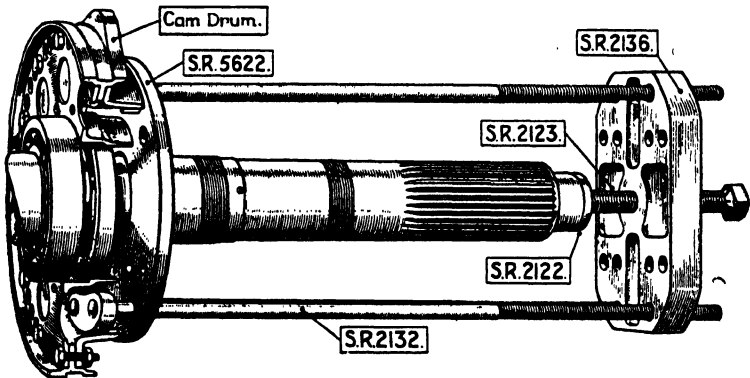


FIG. 4. Extractor for early type cam drum.

Valve operating gear

19. The following procedure should be adopted when withdrawing a cam drum incorporating a cam bearer not provided with a threaded portion for engagement with the later type of extractor :—

- (i) Using the extractor shown in fig. 4, engage the convex faces of the shoes fitted to the draw bolts S.R. 2132 behind the teeth of the cam drum annulus, and locate them by passing the ring plate S.R.5622 over the ends of the bolts and advancing it up to the face of the cam drum.
- (ii) Place the plug S.R.2122 in the end of the crankshaft and screw the extractor bolt S.R.2123 into the yoke plate S.R.2136 so that its ends are flush with the under-face of the plate.
- (iii) Lower the yoke plate over the ends of the two extractor bolts and secure it square with the end of the crankshaft by nuts screwed to the ends of the bolts.
- (iv) By screwing home the extractor bolt, withdraw the cam drum. Great care must be taken to ensure that the cam drum is withdrawn squarely, otherwise the flange of the cam bearer may be distorted.

Induction pipes.

20. When the engine is being dismantled, the outer portions of the induction pipes are removed previous to the removal of the cylinders, and the inner portions previous to the removal of the fan. They are fitted in the reverse order when the engine is being assembled.

Valve timing

21. When setting the cam drum for valve timing, the inlet valve tappet clearance of No. 1 cylinder should be adjusted to 0.060 in. and not to 0.010 in. The crankshaft should be set so that the piston of No. 1 cylinder is $1\frac{1}{2}^\circ$ before T.D.C., and not on T.D.C. before engaging the timing wheels with the annulus and driving sleeve.

Valve clearances

22. All valve clearances must be set to between 0.002 in. and 0.006 in. when the engine is cold.

Ignition timing

23. Both magnetos must be timed 37° early, the maximum permissible error of synchronisation being $\frac{1}{2}^\circ$.

APPENDIX No. 2

LYNX IV AERO-ENGINE

LEADING PARTICULARS

General

Type	Air-cooled static radial.
Number of cylinders	7.
Bore	5 in.
Stroke	5½ in.
Compression ratio	5 to 1.
Reduction gear	None.
Direction of rotation of crankshaft..	Left-hand tractor.
Normal r.p.m.	1,620.
Maximum r.p.m.	1,780.
B.H.P. at normal r.p.m.	170-180.
B.H.P. at maximum r.p.m.	185-195.
Numbering of cylinders (looking at front of engine).	1 to 7, clockwise. No. 1 vertical.

Lubrication

Oil specified for summer and winter use.	To Specification D.T.D. 109.
Oil consumption	2-5 pints per hour.
Normal oil pressure	75 lb. per sq. in.
Minimum oil pressure	60 lb. per sq. in.
Oil inlet temperature	Not exceeding 70°C.

Carburation

Fuel specified	To Specification D.T.D. 224.
Fuel consumption at normal r.p.m. . .	12 galls. per hour.
Type of carburettor	Zenith, type 65G.
Main jet calibration	600 c.c. per min.
Compensating jet calibration	340 c.c. per min.
Slow running jet calibration	140 c.c. per min.
Choke tube, bore	42 mm.

Ignition

Type of magnetos	B.T.H., S.C. 7-1 (Fixed timing)
Port magneto timing	37° before T.D.C.
Starboard magneto timing	37° before T.D.C.
Firing order	1, 3, 5, 7, 2, 4, 6.
Direction of rotation of magnetos (looking at contact breaker).	Clockwise.
Magneto speed	$\frac{7}{8}$ engine speed.
Sparking plugs	As specified in Air Publication 1260.

Valve timing

All valve tappet clearances (hot) ..	0.060 in.
All valve tappet clearances (cold) ..	0.002 in. to 0.006 in.
Inlet valve opens with hot tappet clearance.	1½° before T.D.C.
Inlet valve closes with hot tappet clearance.	41½° after B.D.C.
Exhaust valve opens with hot tappet clearance.	51° before B.D.C.
Exhaust valve closes with hot tappet clearance.	11° after T.D.C.

Installation

Overall diameter of engine	46 in.
Overall length of engine	44.3 in.
Pitch circle diameter of engine bearer bolt holes.	25 in.
Number of mounting bolt holes	16.
Dia. of mounting bolt holes.. .. .	¾ in.

PART I

DESCRIPTION

Introduction

1. The Lynx IV engine is the engine from which the Lynx IV (Mod.) and IV* engines have been developed. It differs from the Lynx IV* engine in the following components :—

- (i) Cylinder unit.
- (ii) Pistons.
- (iii) Connecting rod assembly.
- (iv) Crankshaft.
- (v) Front cover.
- (vi) Valve operating gear.
- (vii) Magneto drive shaft and engine speed indicator drive unit.
- (viii) Induction pipes.
- (ix) Priming system.
- (x) Airscrew hub.

2. Some early engines are fitted with a light type of magneto drive shaft which does not permit of the fitting of a hand starter gear. In this case the drive for the engine speed indicator is taken from the rear end of the magneto drive shaft through a 4 to 1 gear box.

Cylinder unit

3. The cylinder unit is identical with that fitted to the Lynx IV (Mod.) engine and described in Appendix No. 1.

Pistons

4. These are identical with those fitted to the Lynx IV (Mod.) engine.

Connecting rod assembly

5. Although of the split master and articulated rod type, the Lynx IV connecting rod assembly, which is illustrated in figs. 1 and 2, differs considerably from that of the Lynx IV* engine. In the first place, the big end of the master rod is separate from the shank of the rod and is known as the master ring. The latter is split across a diameter and is machined from a steel forging. Besides providing the crankpin bearing, it provides housings for the outer wrist pin bushes of the articulated rods in irregularly shaped flanges machined around each of its ends. The housings are machined in bosses formed on the cheeks; the joint in the ring passes through one pair of these housings. Two pairs of bolts secure the two halves of the ring together, and, as may be seen from fig. 1, one pair is of necessity longer than the other. All four bolts are fitted individually to their sockets and are numbered for assembly, the numbers 1 to 4 being stamped on the heads of the bolts to correspond with similar numbers on the sockets. A castellated nut secures each bolt and is locked by a split pin. The two halves of the ring are lined with white metal; no oil grooves are machined in the bearing.

6. The shank of the master rod is H-sectioned for the greater part of its length, but its inner end, where it is attached to the master ring, is rectangular in section. Two sockets are bored and ground in this end of the rod for the reception of the anchor pins by which the master ring is secured to it. At the points where these sockets are formed, the rod is bossed up so as to fit between the cheeks of the master ring. The anchor pins which secure the master ring to the rod are hollow and parallel-sided and are drive fits in both the master rod and master ring. Circlips sprung into grooves machined in the outer ends of their sockets in the master ring retain the anchor pins against any possible axial movement. The small end of the master rod houses a phosphor bronze floating bush and is drilled with eight oil holes which collect crankcase oil mist to feed the bush.

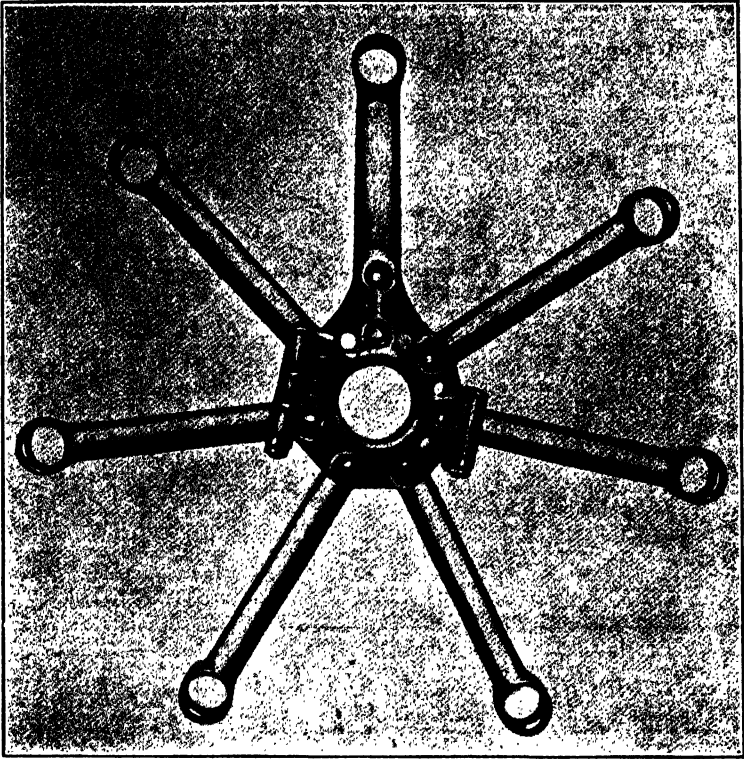


FIG. 1. Connecting rod assembly.

7. The articulated rods are similar to those fitted to the Lynx IV* engine, but they are fitted with floating gudgeon and wrist pin bushes and are attached to the master ring by floating wrist pins. The bushes in the rods are of phosphor bronze and float in their housings, which are each drilled with five oil holes, the bushes themselves being each drilled with six oil holes. In the master ring, the wrist pin bushes are of air-hardened steel and are push fits in their housings. Flanges formed around the inner ends of the bushes locate these components in their housings when the articulated rods are in place. The wrist pins, which are hollow and parallel-sided, are located against axial movement by circlips sprung into grooves machined in the outer ends of their bushes in the master ring. The gudgeon pin ends of the articulated rods accommodate floating gudgeon pin bushes similar to those fitted to the master rods. A single large hole in continuation of the bore of the shank of the rod supplies crankcase oil mist to the bushes in the gudgeon pin ends of the articulated rods. The floating gudgeon pin bushes of all rods are each drilled with eight oil holes. The master ring should be assembled on the master rod so that the part numbers which are stamped on each component are in juxtaposition. When in position in the engine the master rod is attached to the piston of No. 1 cylinder,

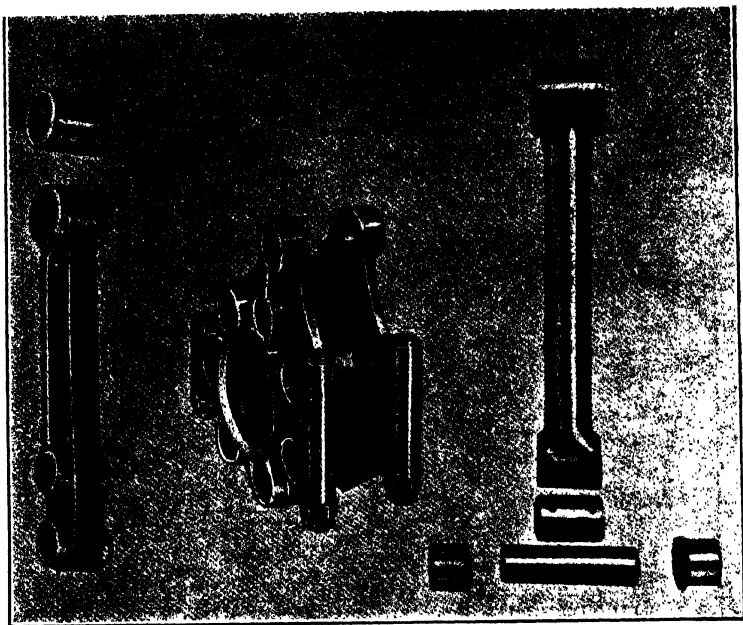


FIG. 2. Connecting rod components.

whilst the articulated rod, the wrist pin bushes of which are accommodated in the split housings of the master ring, is attached to the piston of No. 6 cylinder. All articulated rods, gudgeon pin bushes, wrist pins and wrist pin bushes are interchangeable.

Crankshaft

8. The crankshaft fitted to the Lynx IV is very similar to that described in the main portion of the handbook, wherein, in para. 22, is described the modification to the Lynx IV crankshaft to enable it to be employed in the Lynx IV* engine.

Front cover

9. These engines are fitted with the earlier type of front cover, described in para. 37 of the main portion of the handbook.

Valve operating gear

10. The valve operating gear is identical with that fitted to the Lynx IV (Mod.) engine and described in paras. 8, 9 and 10 of Appendix No. 1.

Magneto drive shaft and engine speed indicator drive unit

11. Whilst some engines are fitted with the same type of magneto drive shaft and engine speed indicator drive unit as the Lynx IV* engine, earlier engines are fitted with a light type of magneto drive shaft which, together with the 4 to 1 reduction gear box used with this shaft for driving the engine speed indicator, is shown in fig. 3. The construction of the front end of the shaft is similar to that of the

heavy type shaft. At the rear end, however, the outer race of the two-row universal ball bearing in which the shaft runs is accommodated in a housing formed in a plate which seals the rear face of the extension of the rear cover. An internal lip is formed at the front end of the housing, the race being held up against it by the lip of a retaining cap. This is an aluminium casting which is attached to the back of the cover plate by three studs and nuts. In addition to effecting the location of the outer race of the bearing, this cap also provides the mounting for the gear box.

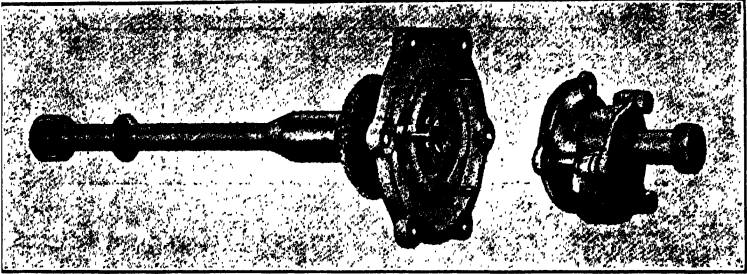


FIG. 3. Magneto drive shaft and engine speed indicator drive unit.

12. A screwed boss formed at the front end of the gear box projects through a central aperture formed in the bearing retaining cap and is secured by a nut. The squared end of the driving spindle of the gear box projects through this boss into a slot cut across the end of the magneto drive shaft. A ring nut screwed to the end of the drive shaft and locked by a tab-washer secures the inner race of the bearing, a pack of adjusting shims and the magneto bevel wheel against a shoulder turned on the shaft. The bevel wheel is keyed to the shaft. Shoulders are formed on the shaft where it passes through the gland in the rear cover and where it enters the coned end of the fan retaining nut, in which it is a clearance fit.

Induction pipes

13. The induction pipes are identical with those fitted to the Lynx IV (Mod.) engine except that no boss for a priming nipple is provided in the flange by which the outer portion of each pipe is attached to the inlet port.

Priming system

14. Instead of the priming system fitted to the Lynx IV* and IV (Mod.) engines, a priming nozzle is fitted in the gas passage in the rear cover of the Lynx IV engine. The nozzle is screwed into the casting in front of, and slightly above, the mounting of the starboard magneto and is connected to some form of priming pump in the airframe.

Airscrew hub

15. Some Lynx IV engines are fitted with the earlier type of airscrew hub as described in para. 114 of the main portion of the handbook. An airscrew hub fitted with one of the early type spiders is shown on the frontispiece to Appendix No. 1.

PART II**MAINTENANCE AND OVERHAUL NOTES****Tools**

16. The tools listed below are peculiar to the Lynx IV engine. In addition, the tools listed in Appendix No. 1 are also required.

Stores Ref. Section 36U.	Part No.	Description.	Classification.	Illustrated in Fig.
4990	S.T.10237	Tool for extracting and inserting anchor pins.	W.2	4
4973	S.R.2154	Tool for extracting and inserting wrist pin bushes in master ring.	W.1	5

General

17. With the exception of the connecting rod assembly, and light type magneto drive shaft, the maintenance and overhaul of the Lynx IV engine is identical with that of the Lynx IV (Mod.) engine. The overhaul of these assemblies is described below.

Connecting rod assembly

18. Before a detailed examination of the connecting rod assembly can be commenced, the articulated rods must be removed from the master ring by removing a circlip from one of the steel wrist pin bushes of each articulated rod and sliding out the wrist pin.

19. The components should be examined as described in A.P. 1464, Vol. I, Part 4, Sect. 4, Chap. 2, paras. 21 to 25. The method of testing the master and articulated rods for alignment is described in Chap. 3, paras. 23 to 27 of the same Section. This method necessitates the removal of the anchor pins in order to separate the master rod from the master ring. Removal of the anchor pins is effected as follows by means of the tool shown in fig. 4 :—

- (i) Pass one of the two sleeves S.T.10237-2 over the end of the extractor spindle S.T.10237-1.
- (ii) Remove the circlips of both anchor pins. Pass the end of the extractor spindle through the bore of the pin to be removed.
- (iii) Pass the second of the two sleeves S.T.10237-2 over the end of the extractor spindle where it projects beyond the cheek of the master ring.
- (iv) Slide the sleeve S.T.10237-3 over the sleeve S.T.10237-2 so that its chamfered face is nearest the edge of the master ring bearing.
- (v) Pass the bearing block S.T.10237-4 over the end of the extractor spindle and screw the nut over the end of the latter.
- (vi) Screw the nut home until the end of the second of the two sleeves S.T.10237-2 is drawn up against the under surface of the bearing block.
- (vii) Remove the nut, bearing block, outer sleeve S.T.10237-3 and inner sleeve S.T.10237-2. Replace the sleeve S.T.10237-3, the bearing block and the nut.

- (viii) Screw the nut home until the further end of the sleeve S.T.10237-2 is drawn up completely into the bore of the anchor pin socket in the master rod.
- (ix) Dismantle the extractor.

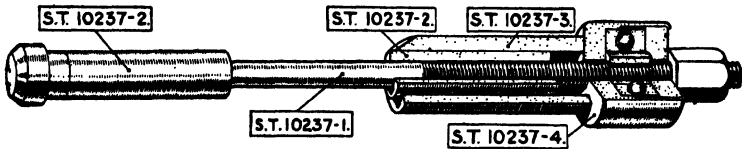


FIG. 4. Tool for extracting and inserting anchor pins.

20. If, owing to wear or signs of overheating or seizure, it is necessary to renew the wrist pin bushes in the master ring, the defective bushes may be withdrawn as follows by means of the extractor shown in fig. 5 :—

- (i) Pass the sleeve S.R.2156, shouldered end first, over the shank of the bolt S.R.2155.
- (ii) Insert the bolt through the bush to be removed from its outer end until its end projects through the bore of the opposite bush.

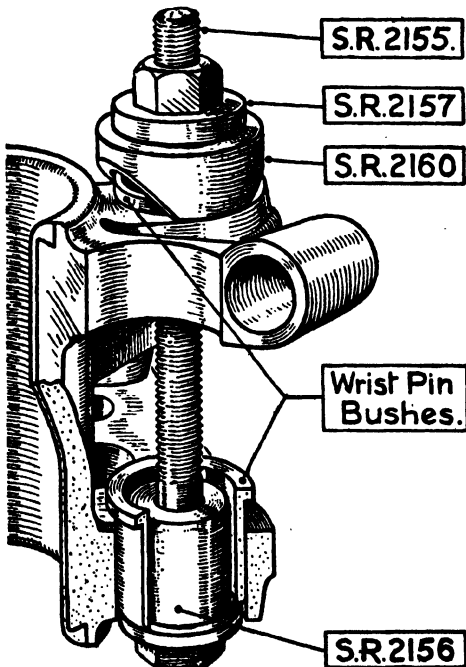


FIG. 5. Tool for extracting and inserting wrist pin bushes in master ring.

- (iii) Place the distance piece S.R.2160 over the end of the bolt so that one of its cut-away sides is located nearest the lip of the master ring bearing.
- (iv) Pass the washer S.R.2157 over the end of the bolt so as to rest on the distance piece and screw on the nut.
- (v) Screw the nut home and thus draw the bush out of its socket.
- (vi) Dismantle the extractor and remove the bush.

21. The steel bushes must always be renewed in pairs ; that is to say, if one of the bushes of a wrist pin is found to be faulty both that bush and its fellow must be renewed. The bushes are drawn up into their sockets as described in para. 23 by the use of the tool mentioned above.

Replacement master rings

22. A replacement master ring suitable for use on a crankpin which has been reground to 2·47 in. fit Z is obtainable. This ring differs from the standard master ring only in the thickness of the white metal. It may be bored to suit any crankpin that has been reground to any diameter greater than 2·47 in. fit Z.

Assembling the connecting rod unit

23. When refitting the master rod to the master ring, the anchor pins, which are marked for assembly, should be drawn up into their sockets by the use of the tool described in para. 20. When drawing the pins home, care must be taken not to draw them in too far, or the grooves for the circlips at the ends of their sockets will be blinded. Having drawn the pins home, fit the circlips in the bores of the sockets and ensure that they are seating correctly in their grooves. The master rod must be fitted in the master ring so that the markings on each component coincide. Should any of the steel wrist pin bushes have been withdrawn for renewal or remetalling of the master ring, they must be refitted as follows by means of the tool shown in fig. 5 :—

- (i) Insert the sleeve S.R.2156 into the flanged end of the bush and locate the latter between the cheeks of the master ring with its plain end nearer the socket to which it is to be fitted.
- (ii) Insert the bolt S.R. 2155 through the socket opposite that to which the bush is to be fitted. Pass it through the bore of the bush and sleeve and out through the socket. The head of the bolt will now be positioned against the flanged end of the sleeve, between the cheeks of the master ring.
- (iii) Place the distance piece S.R.2160 over the end of the bolt so that its cut-away edge clears the edge of the master ring bearing.
- (iv) Place the washer S.R.2157 over the end of the bolt and screw on the nut until the bush is drawn right home.
- (v) Dismantle the tool.

Fitting the articulated rods

24. (i) Oil the bores of the wrist pin ends of the articulated rods and the bores and the outsides of the floating wrist pin bushes. Insert the bushes (which are interchangeable) into the wrist pin ends of the articulated rods.

(ii) Fit the circlips in the bores of the bushes in one cheek of the master ring.

A schematic diagram of a mechanical testing apparatus. It features a central circular component with a radial arm extending from its center. The arm is pivoted at the center and has a weight or mass attached to its end. A circular scale is positioned below the arm, with a pointer indicating a reading. The scale has markings from 0 to 30. A dashed line indicates the path of the arm's tip as it rotates. The entire apparatus is mounted on a base with several circular components, possibly bearings or supports.

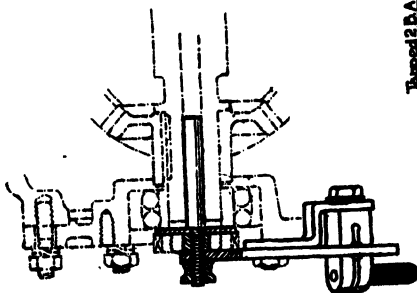


FIG. 5. (APPENDIX №2).

RIG FOR TESTING BACKLASH OF MAGNETO DRIVE SHAFT. (LIGHT TYPE)

(iii) Place the wrist pin ends of the articulated rods between the cheeks of the master ring so that the vent holes trail. Slide the wrist pins home. The articulated rods may be fitted in any position in the master ring, and all the wrist pins are interchangeable.

(iv) Fit the remaining circlips, making sure that they really engage their grooves in the bushes.

Overhaul of the light type of magneto drive shaft

25. The procedure for dismantling the light type of magneto drive shaft is as follows :—

- (i) Unscrew the nuts which retain the bearing retaining cap to the bearing housing and remove the cap complete with the engine speed indicator drive unit.
- (ii) Grip the centre portion of the drive shaft in a lead-jawed vice, and, after bending back the tab washer, unscrew the ring nut from the end of the shaft.
- (iii) Drive the shaft through the bearing by means of a drift inserted in the slotted end of the shaft. See that no packing shims are lost.
- (iv) Drive the shaft through the bevel wheel, which should be supported in a lead-jawed vice. Remove the bevel wheel key from the shaft.
- (v) Tap the bearing out of its housing, using a soft drift applied to the outer race.

26. Examine the shaft for bending, twisting and damage or wear of the splines, key-way, or slot at the rear end. Examine the teeth of the bevel wheel and the ball bearing for cracks, wear or discolouration. Inspect the bearing housing and cap for cracks and the housing for spinning of the outer race of the ball bearing.

27. After examination, the shaft should be assembled as follows :—

- (i) Place the key in its key-way on the shaft and tap the bevel wheel home on to its mounting.
- (ii) Tap the bearing into its housing and secure the bearing retaining cap temporarily to the back of the housing.
- (iii) Place the same shims that were employed previously over the end of the shaft.
- (iv) Tap home the assembly built up in (ii) over the end of the drive shaft.
- (v) Remove the bearing retaining cap, place a tab washer over the end of the shaft, screw home the ring nut and lock it with its tab washer.
- (vi) If it has been removed, refit the gear box to the bearing retaining cap and secure the latter component to the bearing housing, placing a spring washer beneath each of its retaining nuts. Make a joint with liquid jointing compound between the bearing retaining cap and the bearing housing.

Checking backlash between the light type of magneto drive shaft and the crankshaft

28. A rig for checking the backlash between the light type of magneto drive shaft and the crankshaft is shown in fig. 6. When using the rig the bearing retaining cap is removed from the bearing housing and the tongue of the pointer spindle is held beneath the nut at the rear end of the drive shaft. The movement of the pointer is then used to measure the backlash as described in para. 228 of the main portion of the handbook.

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